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PRESIDENTIAL ADDRESS

THE ROLE OF THE AGRICULTURAL SCIENTIST IN INCREASING FOOD PRODUCTION IN AUSTRALIA

By E. J. UNDERWOOD

The demand for increased production

It is now abundantly clear that the world will need food and evermore food if man is not to succumb to his own fecundity. Advances in medicine and hygiene are removing one of the traditional checks on population growth so that the total world population is estimated to be increasing at the rate of 1 to 1½ per cent. per annum. If this rate continues for the next 50 years, it can be calculated that by the end of this century there will be, not 2300 million, but the staggering total of 4000 million mouths to feed. If these calculations are regarded as too fanciful the position during the next 10-20 years is serious enough. The sober and reasoned estimates made in the 1946 World Food Survey by the Food and Agricultural Organisation indicate that by 1960 world food production will have to be increased over the 1939 levels by the following percentages: cereals 21, roots and tubers 27, sugar 12, fats 34, pulses 80, fruits and vegetables 163, meat 46, milk 100.

Meeting this demand

If we exclude the possibilities of substantial contributions from industrial synthesis and microbiology, it is obvious that increases in food production of this order can only come in two ways. These are:—

(i) bringing previously unused land into production,

(ii) increasing the productivity of land already being put to agricultural use.

To a certain extent both alternatives are available although no great, new, easily-developed areas exist in the world such as existed in the 19th century. The possibilities of the huge tropical regions of Africa and South America and of the desert and sub-arctic regions present a formidable challenge to medical and agricultural scientists, but the chief hope for the future undoubtedly lies in increasing the output of existing food-producing areas. There is evidence that considerable scope for improvement exists wherever food is produced but it is in the so-called backward regions of the world, where the population pressure on food supply is the greatest and the output per man and per acre the lowest, that the greatest possibilities occur. Staggering problems have to be faced — problems associated with colossal ignorance and prejudice on the part of the peasant farmers, with oppressive and archaic land tenure conditions, with overwhelming deficiencies in chemical and engineering industry and with transport and communication difficulties. No doubt these problems will gradually be solved and it is pleasant to be able to record the contributions which Australian agricultural scientists are making, through the Food and Agricultural Organisation and other agencies, to their solution. But it is

PROFESSOR E. J. UNDERWOOD, Ph.D., B.Sc.,Agric., is Director of the Institute of Agriculture, University of Western Australia. *The above paper is based on his Presidential Address to the Australian Institute of Agricultural Science at its Nineteenth General Meeting held at Sydney on August* 18-19, 1952.

clear that for many years to come there will be a world shortage of food—a shortage which will be most severe in most of the Asiatic countries and parts of central America but which could become serious even in much more favoured countries such as our own.

During the last 100 years countries such as U.S.A., Canada, Argentina and Australasia have contributed huge quantities of food to Europe and other parts of the world. We have become used to thinking of this as a permanent state of affairs. However, great changes are taking place, changes which are completely altering the pattern of world trade. Population increases and local demands are rapidly catching up with the capacity of these countries to produce. Nowhere is this more apparent than in Australia. Natural increase and large-scale immigration since the war have together resulted in net population increases of about 3 per cent. per annum. The recently-announced modification in immigration policy may reduce this rate of increase slightly, but it is obvious that food production must increase at the same rate as the population if we are to do two things. These are:—

(i) maintain our present extremely high dietary standards,

(ii) continue to export at levels high enough to pay for our very considerable imports and to make a substantial contribution to overseas food requirements.

This dual problem can be helped, but not solved, by drastic import restrictions such as we have recently had imposed, so long as these restrictions are intelligently administered, and by some reduction in our food consumption standards, particularly with respect to meat. There seems no really good reason why the average Australian should consume 5lb. of meat per week when the average consumption in U.S.A. is under 3lb. and in Great Britain barely 1lb.

The major solution must come, however, from *increased food production.* Over the last few years, instead of increases, there have been small but steady falls in the total production of several of our key primary products, notably wheat, meat and dairy produce. This contrasts strikingly with the great expansion of secondary industries in Australia since the war. When these falls in production are linked with a rising local consumption over the same period the result has been a substantial fall in the volume of exports. Until this last year the abnormally high prices for wool so swelled the *value* of exports that the serious fall in the *volume* of exports was masked and appreciated by few.

Factors limiting expansion

Before proceeding to consider ways and means of increasing food production in Australia and the part which the agricultural scientist can play it is logical to examine the reasons for the failure of food production to expand at a rate comparable with secondary industries.

So much has been written and spoken on this subject in recent months that I propose to outline them only. I would refer particularly to the article by Strong (1952). In general terms it seems they can be grouped as follows:—

(i) Dissatisfaction with prices (other than wool).

(ii) Shortages of farm equipment and materials.

(iii) Lack of farm labour.

(iv) High taxation.

(v) Lack of credit, particularly in relation to butterfat production.

(vi) Declining soil fertility, particularly in relation to wheatgrowing.

It will be noted that five out of the six factors quoted are what might be called politico-economic. It might be argued that only item (vi), declining soil fertility, can be considered technical in

character and therefore of direct interest to the agricultural scientist. I wish categorically to oppose this point of view. Quite apart from the fact that the agricultural scientist is a citizen as much as any other member of the community, and should be better informed and more outspoken on these important matters than others, it must be realised that technical and economic factors are often closely related and frequently influence each other. *Agricultural research and extension in Australia have suffered too long from an almost exclusive devotion to technical problems and a severe neglect of economic and sociological problems.*

Value of research and extension work

Technical research and advisory work have paid rich dividends in Australian agriculture and represent contributions to the welfare of this country of which this Institute can justly be proud. It is essential that such work should continue and expand but, in addition, I would like to see an even greater expansion in the fields of rural economics, farm management and rural sociology, with the closest possible liaison between the two types of activity. What little there has been of agricultural economics in Australia, has been largely confined to cost and price studies of a statistical nature and has not concerned itself with the economic and management problems of the individual farm and their relationship to efficiency and production. Beattie (1952) has emphasised this point with particular reference to the Australian beef cattle industry.

Almost every thinking person, and certainly every member of this Institute, will agree that greatly expanded research and advisory services are necessary if Australian farmers are to produce the greatly increased quantities of food needed now and in the future.

Research

I have placed research first for two reasons. The first is that any extension service needs a continuous flow of new knowledge if it is to remain effective. Research must be ahead of practice in any industry. The second is that we are constantly being told, particularly by economists, Ministers of the Crown and Under-Secretaries for Agriculture, of the "great gap" which exists between scientific knowledge and the putting of this knowledge into farm practice. I would be the last to deny that such gaps exist and it is certainly easy to find plenty of examples. *It is equally easy to find gaps in the knowledge which the advisory officer must have if he is to give worthwhile help to the practising farmer.*

The outstanding example of this research gap, in terms of importance to Australian agriculture, is surely in relation to the maintenance of cereal crop yields and soil fertility in the drier parts of the wheat belt of southern Australia. What effective advice can the extension worker give the farmer in these areas at the present time? To put it more cogently, what could ten times the number of extension workers tell these farmers at the present time? He knows that the land is being cropped too frequently, that fallow accelerates soil depletion and increases the erosion hazard and that longer rotations are the answer in technical terms. But fallowing is essential for reasonable crop yields and longer rotations are economically impossible without productive pasture legumes for the grazing years. For a very high proportion of the Australian wheat belt no such pasture legumes are yet available and the amount of research being carried out to find or produce them is pitifully small. This was pointed out by Davies (1952) in his presidential address to the Institute last year. In fact, genetic research, designed deliberately to produce improved pasture legumes for the drier parts of the wheat belt of southern Australia, is almost entirely confined to a small group at the University Institute of Agriculture in Perth, which only commenced three

years ago and even now is spending only a few paltry thousands a year.

Research of this nature must, of course, be linked with experiment station and farm investigations and demonstrations designed to determine the most efficient rotations for particular districts and their effect on crop yields, stock-carrying capacity and soil fertility. The position in this respect is not much more satisfactory than in respect to the basic genetic research just mentioned. I would like those individuals who constantly cry of the "great gap" between research and its application to know that in one State all the wheat belt research stations were closed as an economy measure in the 1930's and are only now being partly re-opened; in several other States their budgets have been severely pruned. These research stations should be carrying out the "key" applied research for their districts and providing the constant stimulus and stream of new knowledge which are essential if the field advisory officers are to do a worthwhile job.

A further example of a serious gap in our knowledge lies in the fields of farm economics, farm management and rural sociology, which I referred to briefly a moment ago. *In each state there should be regular farm surveys, carried out in collaboration with the district advisers, aimed at defining the economic, "managerial" and technical factors influencing farming efficiency and farm incomes.* Such surveys would provide a body of factual data on the relative importance of these factors and the extent to which approved farm practices are, or can be, used. They would provide an intelligent basis for extension work and define the most important research needs. If these surveys included also information on the farmer and his family—their interests, aspirations, living conditions and educational background—they would be still more useful and would give the advisory officer greatly increased chances of success.

In case some of you are doubtful of the value of these proposals I would like to illustrate my point with three examples —two from Western Australia and one from New South Wales. Dairy advisers in the main butterfat-producing areas of Western Australia have for years been exhorting farmers to use better bulls, to conserve more hay and silage and to feed phosphatic licks. This is good advice, but farm surveys carried out during the last few years by workers at the University Institute of Agriculture have revealed the fact that even the full acceptance of this advice could do little to improve the lot of most farmers. More than 50 per cent. of the farms surveyed have too few cows and too few acres of sown pasture to have any real hope of economic success. Their primary need is better credit and equipment facilities for increased clearing and pasture development to raise their "scale of enterprise". Surely the trained extension officer should be the one to give the lead in these matters. That he so rarely does so is due, in my opinion, to the fact that his viewpoint is too narrowly technical—is not imbued with what is described in New Zealand as the "whole farm approach" and that he has not the right data on which to work.

Consider also the significance to extension workers of a more recent finding from a university survey in these areas. It was found that 80 per cent. of the 120 dairy farmers in the survey, which was a random selection from a total of 1,500 in the districts concerned, had received no formal education beyond the primary school or age 14, and 78 per cent. had no idea of their net business profit or loss for the year. Clearly some elementary help in the keeping of systematic farm records is one of the first requirements of these farmers if they are to gain any understanding of the working of their own farms.

My last example comes from an exceedingly valuable survey recently carried out. (Parish, 1952). This survey covered 86

farms in districts of the western slopes and eastern Riverina of New South Wales. Among a great deal of interesting and valuable data it lists, in order of importance, the reasons given by farmers for growing less wheat. Far ahead of all others were declining soil fertility, i.e., the need for "spelling the land" and skeleton weed. These are intimately related because the severity of skeleton weed infestation is greatly reduced by less frequent cropping and by pasture development with subterranean clover and Wimmera rye grass. The significance which the farmers attach to declining soil fertility, due to too frequent cropping in the short rotations typical of the area, is important enough but still more important is the fact that most of them believed that "spelling the land" was the answer. There was not the same awareness of the need for productive leguminous pastures to increase stock-carrying capacity in the non-cereal years, to eliminate the need for fallow and to maintain and improve the nitrogen and organic matter status of the soils. The elimination of the several million acres of bare fallow, the "cornerstone" of Australian agriculture, which exist in Australia every year, would be of enormous benefit in increasing wheat production once the fertility of the soil was maintained at a high enough level to make this possible. The findings of the survey point in no uncertain manner to the urgent need for advisory and demonstration work along these lines in order to raise wheat production without further soil deterioration.

Extension

I wish now to make some references to agricultural advisory services in Australia and the recent Commonwealth Government grant of £200,000 to the states for this year. It is my belief that this substantial recognition of the need for an expansion of such services was helped in no small measure by the active interest of this Institute in this subject over the last few years. It is my hope that the Institute will influence the position further. In particular, there are two things which seem to me to be well worth pressing for now, when there may be some difficulty in spending usefully the whole of the first year's grant. The first is that a small proportion, say 5 per cent. be set aside for surveys designed to estimate the effectiveness of the various forms of extension which already exist and the extent to which farmers avail themselves of them. The surveys could best be undertaken by the universities in view of their independent status and lack of direct responsibility for extension activities. No such investigations have yet been carried out in Australia, although they have yielded useful results in U.S.A. They appear to be a logical and intelligent basis upon which an expansion of extension services should be built.

The second concerns the training of extension personnel. Most people now agree that a university degree in agriculture is a basic requirement but there is little agreement on the amount of direct training in extension methods which should be included in, during or after the course, and still less agreement on the amount and nature of "in-service" training which should be given. Several of the states, and more recently C.S.I.R.O., have organised a number of "schools" for advisory officers which have been entirely concerned with improving the knowledge of these officers in particular fields. These are important and valuable but, with the exception of the N.S.W. Department of Agriculture, these schools have not tackled problems of methods and approach in extension work. I would like to see the Institute sponsor an enquiry into the whole matter of extension training by means of a small committee containing representatives of both the universities and the state departments of agriculture.* This proposal also appears

*Such a committee of the Institute has now been formed.

a necessary first step in an expanded extension service and could well constitute an important contribution to increasing the status and effectiveness of our members who have chosen the field of extension for their life's work. At present extension suffers in standing and prestige in comparison with research. To some extent this is due to the attention given at the graduate level to specialised training in the methods and techniques required of the research worker. There is little doubt in my mind that similar attention should be given to specialised training in methods and techniques for the extension worker. The cost of such an enquiry and report would not be great and could justifiably also be financed from the commonwealth grant to the states.

In conclusion, I wish to emphasise that I have not attempted in this address to discuss all the various ways in which the agricultural scientist can help in increasing food production in Australia, or all the factors which are at present limiting this production. I have purposely concentrated on certain avenues of activity, both for the individual and for the Institute as the professional organisation representing agricultural science, which seem to me to have been neglected in the past and which must be fostered and developed if agriculture is to fulfil its proper destiny in the future of this great country and of the world as a whole.

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ARTICLES

THE FUTURE FOR RUST RESISTANT WHEAT IN AUSTRALIA

By I. A. WATSON and D. SINGH

Introduction

Workers in this country have been prominent among those who have striven to control the ravages of cereal rusts by breeding. Several stem rust resistant varieties of wheat have been evolved at various times, but the most valuable of these have had only a short life as field resistant varieties. At present in New South Wales there is no variety grown in any quantity that possesses resistance to stem rust, is of good agronomic type, and is readily acceptable to the milling and baking industries. Celebration, Warigo and Fedweb are among the resistant varieties but they are not popular for one or more important reasons.

The fate of resistant varieties

The extensive cultivation of a resistant variety immediately after its release has in most cases resulted in the detection of a rust that was previously unknown, and which is capable of attacking it. Several cases of this kind can now be cited. Eureka became susceptible to stem rust in 1942. Gabo became susceptible to leaf rust in 1945; stem rust attacked Charter, Kendee, Gabo and Yalta in 1948 and Warigo was susceptible to leaf rust at Castle Hill in 1951 (Watson and Baker, unpublished). In all cases it can be shown that the rust responsible was one closely related to one of those present previously, but having the additional capacity to attack a variety formerly resistant.

Questions concerning the origin of these rusts have been asked many times. Although no clear experimental proof can be given, the circumstantial evidence is very much in favour of their having arisen by mutation. Several cases of mutation in cereal rusts are well known in the literature. Some will argue that the role of the barberry has not been eliminated, but this alternate host is so sparsely distributed in the areas where wheat is grown that infection from viable teleutospores must be very rare. Moreover, the clear affinity between the old and the new rusts would lead us to the view that hybridisation and recombination during a sexual stage has not occurred. The likelihood of barberries being unimportant is increased by the situation with wheat leaf rust *(P. triticina)*. Waterhouse (1952) over a period of 30 years has demonstrated that more than 10 races of this organism have occurred at various times in Australia, and most of these have been collected in the field. Infection of *Thalictrum* spp., the alternate host, has never been observed under field conditions in this country. Mutation in the fungus was probably responsible for the changes in pathogenicity.

The relation of the old and new rusts

At one time it was considered that the physiologic races of wheat rusts as described by their reaction on a set of varieties were stable. On this assumption workers in different countries of the world followed the lead of Stakman and others and classified the various types of stem rust present according to their reaction

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on a group of varieties. Other quite different sets of varieties were found capable of separating the races of leaf rust, so that to-day there are available duly acknowledged catalogues of races of leaf rust and stem rust of wheat. An appropriate number can be assigned to any rust provided its combination of reaction types conforms to one already described in the catalogue.

Waterhouse has pointed out in several publications that the sets of varieties selected elsewhere are not necessarily the best for Australian conditions and in fact they may be quite inadequate as a means of describing our rusts. The inadequacy of these sets, selected particularly by the United States workers, is becoming increasingly apparent at the present time. This has resulted from the commercial cultivation in Australia of varieties having as sources of resistance, genes (resgenes) (Watson, 1952) not included among those possessed by varieties within the above-mentioned sets.

Prior to the cultivation of Eureka, rusts closely allied to race 126 formed the bulk of the stem rust inoculum. This rust was designated race 34, but it was shown by Waterhouse and Watson (1941) to be very unlike an American culture having the same race number. No one of these rusts was known to be capable of attacking varieties having the genes from either Kenya 743 (C6040) or Kenya 745 (C6042), (varieties carry the Sydney University Accession Number). Subsequently a rust was isolated from Eureka which although showing slight differences from the old type gave reactions within the range of race 126. It was designated race 126 B (Watson and Waterhouse, 1949) and was shown to be closely related to race 34.

The unexpected setback suffered by the susceptibility of Eureka was overcome to some extent by the release of Charter, Kendee, Gabo and Yalta. But by 1948 rust was found on them (Waterhouse, 1952). The rusts responsible were of two types, and they could be separated on the basis of their ability to attack all varieties having the Kenya 743 resistance. Extensive tests by Waterhouse showed that in addition to 126 and 126B two other rusts were present; these he has designated races 222 AB and 222 BB. Apart from their ability to attack varieties with the Kenya 745 gene these two biotypes of race 222 are different from race 126 on Kubanka and Acme.

Race 34 was, and biotypes of races 126 and 222 still are, important from the Australian point of view. The two main varieties of the differential set on which the reactions differ are Kubanka and Acme. Their reactions according to the accepted scheme are:—

	Kubanka	Acme
race 34	4	4
race 126	X	X
race 222	1	1

Waterhouse's results (1952) indicate that race 34 was prevalent prior to 1942 and that races 126 and 222 have been isolated frequently since. Despite the fact that different race numbers have been assigned, these rusts are very similar when examined on the usual set of varieties. Watson and Waterhouse (1949) have shown (Table 10 of that paper) that race 126 and race 126B give a range of reaction on Kubanka from ; to X depending on temperature. Acme also shows a variable reaction. In view of these results a separation of races 126 and 222 on these varieties would be most difficult through a wide range of temperature since the isolates of race 222 studied by Waterhouse give such a low reaction type.

Although these slight differences can be detected in isolates of races 126 and 222 under carefully controlled conditions, separations can be made with certainty on Kenya 743 and Kenya 745. Varieties having the genes for resistance from these parents are equally valuable, and they are essential for studies concerned with physiologic race surveys in Australia.

The significance of commercial rust resistant varieties in the composition of the rust flora

It is of importance to note that these genes did not become valuable in differentiation until varieties carrying them were brought into commercial cultivation. Prior to the widespread use of Eureka, no rusts were found in Australia to which it was susceptible. It was suggested (Watson and Waterhouse, 1949) that a mutation had occurred in the rust and this rendered Eureka susceptible. Rusts of race 222 have probably arisen by mutation also, and they have been detected as a result of the extensive cultivation of varieties which provide a medium favouring their development and restricting the growth of other rusts.

The part played by the variety in determining race distribution is now becoming clear. Race 126 is an aggressive type and probably would still be predominant in the absence of the restrictions that have been placed upon it. Such restrictions in the form of resistant varieties are not evident in the south west of New South Wales, and and race 126 is therefore still abundant. This was clear from two series of collections taken during the 1950-51 season. One was made to include Wagga and Temora, districts where susceptible varieties are largely grown, the other was made at three places around Gunnedah where the varieties grown would limit either 126 or 126 B. The results are given in Table I.

It is probably correct to argue from this that had it not been for the release of resistant varieties only limited variability in the rust would have been detected. If growers had continued with the cultivation of susceptible varieties, would these new rusts have shown the spectacular increase? To obtain some information on this point, the four rusts, races 126, 126B, 222AB, and 222BB were cultured in various mixtures on Federation, a variety susceptible to all. Nine mixtures were grown through five generations as shown in Table II.

The mixtures were analysed by the method previously described (Watson, 1943). It will be seen from the table that in no case has the newer rust shown any spectacular advance over 126. In these data the ability of this latter rust to maintain itself and actually to increase when given equal opportunity becomes strikingly evident. By contrast, the survival rate of race 222BB is poor. Although this rust possesses a wider host range than the other three, it appears unable to compete with them on Federation.

The figures obtained on seedlings in the glasshouse are in accord with those obtained in the field, and lead to the conclusion that changes in virulence are not necessarily associated with all-round aggressiveness on media favouring other rusts.

Varieties at present resistant

In spite of its poor competitive ability, race 222BB is the rust of greatest concern to breeders at the present time. But will the others be important as providing inoculum from which further mutations

TABLE I

Results of race determinations made in two centres of the New South Wales wheat belt in 1950

Centre	Races identified						
	126	126B	126 ⟩mxd. 126B⟨	222BB	222AB	222AB ⟩mxd. 222BB⟨	Total
Wagga-Temora	19	7	2		1	1	30
Gunnedah	—	—	—	8	85	2	95

TABLE II

Percentage of each rust when grown in nine different mixtures through five passages on Federation

Mixture	Races	Number of passages through Federation				
		1	2	3	4	5
1	126	69.0		85.5	86.4	88.8
	126B	31.0		14.5	13.6	11.2
2	126B	71.3		90.4	90.8	86.5
	222BB	28.7		9.6	9.2	13.5
3	126B	61.1		58.6	56.6	47.7
	222AB	38.9		41.4	43.4	52.3
4	126	84.9	92.3	96.6	97.8	95.2
	222BB	15.1	7.7	3.4	2.2	4.8
5	126	65.7	61.5	82.1	77.0	72.6
	222AB	34.3	38.5	17.9	23.0	27.4
6	222BB	65.6	80.0	4.7	8.3	5.2
	222AB	34.4	20.0	95.3	91.7	94.8
7	126	57.9	88.6	68.5	63.8	74.2
	126B	33.2		30.4	35.4	25.4
	222BB	8.9	11.4	1.1	0.8	1.4
8	126	52.9	64.9	68.1	78.1	71.5
	126B	9.4		4.0	3.2	3.7
	222AB	37.7	35.1	27.9	18.7	24.8
9	126	66.2	79.3	92.1	89.7	87.2
	222BB	19.9	20.7	1.1	0.8	0.5
	222AB	13.9		6.0	9.5	12.3

will be produced? Festival and Dowerin are two commercial varieties known to have the resistance of Kenya 744 (C6041). The gene responsible for this is independent of those in Kenya 743 and 745 (Watson and Waterhouse, 1949). Kenya 117A 1347 is another variety with a gene different from any of the three above and varieties having this gene will be available shortly for commercial cultivation. If past experience is repeated, these genes can be expected to be rendered ineffective by further changes in the fungus. Kenya 117A 1347 is of special interest in that it possesses a genotype giving it resistance against a large number of races that occur in various parts of the world.

It might be assumed to possess a gene for resistance superior to that in other varieties. That this is probably not so would appear from results in Kenya where it became susceptible soon after its release for commercial cultivation (Thorpe, private communication). It has already been pointed out that such widespread resistance of a variety can be interpreted as indicating a low frequency in the population of the pathgene specific for Kenya 117A 1347 (Watson, 1952). If this speci-

ficity exists between pathgene and susgene, then widespread resistance could be interpreted as a low mutation rate at the locus of the pathgene responsible for Kenya 117A 1347 susceptibility. There are no suitable data yet to explain the reasons for the differences in effectiveness of resgenes possessed by various varieties, but until that is available it appears wise to concentrate on those genes giving the widest resistance.

Varieties of the future

The happenings with stem rust outlined above are parallelled by those for leaf rust, and it seems from the results to date that the step by step increases in the range of pathogenicity are proceeding in *P. triticina* as well. The question may well be asked. Will a lasting resistance ever be evolved? On our present knowledge this cannot be answered, but two helpful suggestions have been made (Watson, 1949) (Watson and Waterhouse, 1949) (Pugsley, 1952).

1. Breeding programmes aimed to prepare for the occurrence of new rusts should be based on genetically diverse resistant parents.

2. Combined resistances where possible should be used.

In considering the first of these suggestions it must be stated that the lack of genetic diversity was responsible for the simultaneous collapse of Gabo, Charter, Kendee and Yalta as stem rust resistant varieties when race 222AB, and 222BB appeared. All four varieties have a common gene. These same varieties which were of value in India as resistant parents became susceptible with the occurrence of race 15C. It was always fully realised that these varieties might become susceptible owing to the presence of new rusts. A programme was commenced to build additional resgenes into these varieties, but the rusts appeared before much headway had been made.

In regard to the second point, most observers would agree that a variety having a combined resistance would be preferable to one having a single resistance. We mean here the combination of two genes each of which controls resistance to all the local rusts present. The bringing together of two genes each giving resistance to only a portion of the total rusts would not be a combined resistance in this sense.

Once the mode of inheritance is known, and provided the right races are present, combinations of non allelic genes can be made readily. In the absence of specific tester races, the method of Macindoe (1948) can be used for combining genes operating at two different stages of growth. Pugsley used backcrossing in conjunction with this method to derive his E.W.G., a line combining Eureka, Warigo and Gabo. This line, however, must now be regarded as having the Warigo gene as its only effective resistance since rusts capable of rendering ineffective the two other genes are available.

Mutations in relation to combined resistance

Without the actual experience, it is impossible to say with certainty that two genes combined will give a more lasting resistance, but the happenings have indicated certain possibilities. The step by step increases in the range of pathogenicity of the Australian rusts would lend support to the mutation theory as explaining the origin of new types. These latter appear to involve with each step a different gene in the host. From the work of Johnson and Newton (1940) and of Flor (1946) this probably means that when a gene in the host becomes ineffective, a single locus in the fungus has been involved in the change. Cases may arise in the fungus in which mutations affecting two loci occur simultaneously, or a mutation at one locus may affect two independent genes in the host. However, the probability of getting the former should be rather low, and under our conditions there is no evidence of two genes in the host being affected by one mutation in the fungus. Extensive seedling tests on many varieties have failed to reveal a gene other than that in Kenya 743 which will separate races 126 and 126B or races

TABLE III

The reaction of varieties having the resgenes from Kenya 743 and Kenya 745 singly and in combination against four phenotypes of rust.

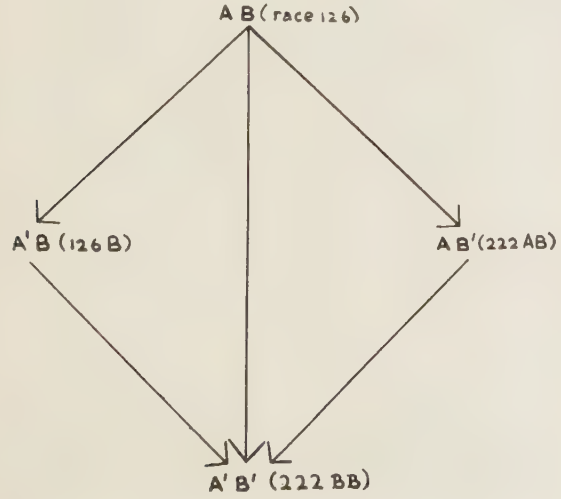
Race	Supposed Phenotype of Rust	Host		
		Kenya 743	Kenya 745	(Kenya 743 & 745)
126	AB	R	R	R
126B	A′B	S	R	R
222AB	AB′	R	S	R
222BB	A′B′	S	S	S

R = Resistant. S = Susceptible.

222AB and 222BB. In the cases reported by others, however, (Newton and Johnson, 1939), several host genes have been involved simultaneously in the mutation reported.

If we assume that two separate loci in the fungus are concerned with the pathogenicity on Kenya 743 and Kenya 745, the relationship between the fungus and the host can be shown as in Table III.

A and B represent the inability to attack Kenya 743 and Kenya 745 respectively. A′ and B′ are mutations at these loci and are characterised by their virulence on the varieties shown. Whether separate loci are involved will not be known until the appropriate crosses are made on the barberry, but for the time being race 222 can be considered as A′B′ having arisen from AB in two steps or in one step thus:



This theory for the origin of new rusts is basic to the breeding programme at the University of Sydney. Only time will tell whether the method has advantages over that which aims to incorporate single resistances. The essential steps in the first part of the work have already been given (Watson, 1949) using Eureka as one of the recurrent parents. Several donor parents known to have different factors for resistance to all Australian rusts are contributing to genetic diversity, e.g. Kenya 117A 1347, K.D. 1451 (a derivative of Khapli emmer), Hofed 1200 Egypt 1228, T.D. 1656 (a derivative of *Triticum timopheevi*), Thatcher 1201 and A.D. 1960 (a derivative of *Agropyron elongatum*). Soon these resistances will be available in a background of genes mainly from Eureka. The genetical studies which are now in progress will give us the necessary information regarding the possibility of combining these resistances. If four different resgenes A, B, C and D are independently inherited, it will be possible to derive six combinations, i.e. AB, AC, AD, BC, CD, BD.

Since these six lines will be derived by backcrossing and selection they should all be agronomically desirable types for commercial cultivation. If they are released to growers, rust will be present on susceptible varieties and it will, as before, mutate at a rate influenced by environmental conditions. New varieties of course will not change the mutation rate; they will simply serve to detect new types. Should

mutations occur affecting gene A, then the variety contributing it will become susceptible. One affecting gene B will attack the respective donor parent. Genes C and D will continue to show resistant reactions despite these particular mutations. Mutations may also occur affecting them however. Two genes A and B may be affected simultaneously, but this would happen very rarely.

Table IV shows the results from mutations of three types rendering ineffective (1), gene A; (2), gene B; (3), genes A and B.

While mutations at single loci affect the varieties not one of the six derived lines would become susceptible. Even with a mutation at two loci only one of the six lines would show rust, and if all were released at the one time, most would continue to be useful commercial varieties.

Such an undertaking as that given for stem rust would be essential if protection against leaf rust is also envisaged and this work is well in hand using appropriate sources of resistance. Various combinations of genes for leaf rust resistance are being made with those for stem rust, all in genotypes of proved adaptability. The expectancy is that a combination of genes for resistance to stem rust will be more successful than single resistances. The same will apply to leaf rust. Even so the problem will not be complete. New rusts will continue to appear and new combinations will be necessary to combat them. The synthesis of the latter must therefore proceed and the search for new resistances must be continued with even greater vigour than at present.

The detection of new types of rust

Whatever the approach to the problem of breeding rust resistant varieties, it is essential that all aspects of variability in the pathogen should be studied. The production of new and more virulent rusts by artificial means would be a distinct help in the breeding work and should be investigated, but the dicaryotic nature of the rust mycelium will reduce the frequency of visible recessive mutations. All phases of hybridisation on the alternate host will require close study to reveal the pathogenic potentialities of the recessive genes now hidden in the existing rusts.

A close examination of rusts collected from widely separated areas within Australia will reveal something of the variability to be expected. This variability can be measured by the rust reactions of a set of varieties having specific genes. The desirability of having within any differential set the resgenes of our commercial

TABLE IV

Reaction of four donor varieties and six derived lines to three different mutations in rust

Variety			Mutation rendering ineffective		
			Gene A	Gene B	Genes A and B
Donor	Parent	AA	S	R	S
,,	,,	BB	R	S	S
,,	,,	CC	R	R	R
,,	,,	DD	R	R	R
Derived	Line	AB	R	R	S
,,	,,	AC	R	R	R
,,	,,	AD	R	R	R
,,	,,	BC	R	R	R
,,	,,	BD	R	R	R
,,	,,	CD	R	R	R

R = Resistant. S = Susceptible.

varieties has already been mentioned, and is evident from Waterhouse's latest work (1952). In fact it is becoming very clear that the first need is a determination of Australian rusts on a set of resgenes selected locally. It would seem from the results to date that the same set of genes would be useful throughout Australia. Sets of genes different from those used here will probably be necessary elsewhere. Each geographical region would need to have its own gene set, to distinguish more easily the rusts present. Current studies make it abundantly clear that the set used here would not be suitable in India, and there are many other such cases. While such a procedure will meet our requirements better, the general relationships that exist between the rusts of this and other regions can be found from time to time by testing representative samples on a common set of differential varieties.

In addition to making more use of locally important genes in describing the rusts, we suggest that valuable data would accrue from using genes of future varieties among the differential set. Kenya 117A 1347 for example, is not the parent of any commercial variety in Australia but it probably will be shortly. By exposing it to collections from widely separated areas, more would be known of the limits of its resistance. If surveys could be based on such varieties, together with those that best separate the rusts of an area, adequate differentiation would result and valuable resistances become apparent.

Summary and conclusions

The changes in the rust flora in Australia discovered over the last ten years are assumed to be due to mutations. The cultivation of varieties of wheat having specific resgenes serves to detect these new types which otherwise pass unnoticed.

When examined closely these new rusts appear to have increased their range of pathogenicity in steps, each step involving a single new gene in the host. At present there is no evidence of a change involving two host genes simultaneously.

On this understanding of the origin of new rusts is based the programme of breeding now in progress at the University of Sydney. This involves the incorporation of pairs of genes for resistance into a basic genotype that is well adapted to local conditions. When these derived types are evolved it is expected that they will remain resistant in the field for longer periods than similar types having single resistances.

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A REVIEW OF PROGRAMMES FOR AGRICULTURAL RESEARCH IN AUSTRALIA

By H. C. FORSTER

INTRODUCTION

When the first settlers arrived at Sydney Cove in 1788, they found a difficult country of poor soils, harsh climate and sparse vegetation. In the first years of settlement, they were barely able to grow enough agricultural produce to supply their own immediate needs and Governor Phillip had to take extreme steps to save the settlement from starvation.

Although subsequent exploration and settlement brought to light many areas of better inherent agricultural potentialities the difficult Australian environment with its low rainfall, its frequent droughts and high temperatures, and its large areas of less fertile soils has presented a challenge not only to the practical farmer, but also to the scientist.

The early years of agricultural development involved much hard labour and initiative in modifying English farming practice to Australian conditions. By the middle of the nineteenth century, however, agriculture became established as a vital activity of the country and wheat and wool began to be exported overseas.

The establishment of State Departments of Agriculture from about 1880 onwards, supplemented in later years by Commonwealth and University research institutes, has provided the means for the conduct of the research and investigation which has assisted greatly in achieving the great expansion in agricultural production of the present day.

DEVELOPMENT OF RESEARCH PROGRAMMES

A review of the broad aspects of the development of the research programmes during this period* should prove of interest and value and may enable us to point to the gaps in our knowledge and the aspects which should receive attention in the future.

The period to the first world war

Initial investigation and research in plants was concerned mainly with improvement of cereals, particularly with the main export crop, wheat. The success of Farrer from 1886 onwards in breeding varieties of wheat better adapted to the shorter Australian length of day and of improved drought resistance was an outstanding scientific achievement. Following in his footsteps, later plant breeders in the different states improved yield still further by adapting varieties to the particular soils and climate of their wheat-growing districts.

On the soil side, Custance and Lowry, at Roseworthy Agricultural College, were responsible during this period for the major contribution of demonstrating the basic lack of phosphate in Australian soils and for establishing the necessity for preceding the wheat crop by a period of bare fallow to conserve moisture and essential plant nutrients such as nitrates.

*Greater detail is presented in the Review of Progress of Agricultural Science in Australia 1901-1951, which appeared in Vol. 17, No. 2, of this Journal.

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The greatest achievement in the animal field was the adaptation by cross breeding and selection of the original imported strains of Spanish Merino, Rambouillet and Saxony sheep to produce the Australian Merino, combining fine quality wool production and ability to thrive on the sparse pastures and herbage of the lower rainfall districts of this country.

The period between the two world wars

Research activity during this period was stepped up considerably as a result of several important factors.

With the establishment of Schools of Agriculture and of Veterinary Science in several of the state universities during the early years of this century, a regular, though small, flow of scientifically-trained men became available for the first time for work in the agricultural field. From 1920 onwards, the number attending these schools increased materially.

The establishment also of the Waite Agricultural Research Institute in 1924 and the formation of the Council for Scientific and Industrial Research by the Commonwealth Government in 1926, provided further facilities for an intensive programme of investigation and basic research in agriculture. State Governments also recognised the importance of their Departments of Agriculture to a greater degree and supported them more generously.

As a result, the field of research was widened considerably. Recognising the need for a more thorough knowledge of the soil itself, soil surveys were initiated to provide a sound basic grounding for agricultural settlement. Intensive studies on the chemistry of soils amplified the knowledge of availability of the major soil nutrients of phosphate and of nitrogen. Of particular significance was the discovery by Piper, in 1931, and the further work of Leeper, defining manganese deficiency as the cause of "grey speck" disease of oats. The importance of copper and zinc in plant nutrition followed during the latter part of the thirties. This marked the beginning of a number of investigations into micro-element mineral deficiencies, a field in which Australian scientists have contributed considerably to world knowledge.

The outstanding feature of plant research in this period was the recognition of pastures as the most important crop in Australia. Although the value of superphosphate in increasing growth of pastures was recognised prior to World War I, it was not until the value and importance of subterranean clover was appreciated some ten years later that much attention was paid to this field of work. Although science cannot claim to have played any part in the initial recognition of subterranean clover's peculiar suitability to the southern Australian environment, research has followed up the discovery in developing high-production pastures for large areas of the better rainfall regions. Considerable attention was given also to the establishment and selection of the best strains of perennial and annual pasture grasses and clovers for both natural rainfall and irrigation areas. The significance of pastures with their accompanying livestock in maintaining and improving soil fertility and thereby providing a sound basis for a continuing agriculture cannot be too greatly stressed.

Research in cereals during these years was directed mainly towards increasing yield by breeding better varieties and by improving general cultural methods and fertilizing practices. Considerable attention was also given to improvement of quality and the breeding of varieties resistant to disease. Major advances were made in Queensland along similar lines in establishing the sugar industry on a sound scientific basis.

Several important contributions to the control of insect and fungal pests were made by Australian scientists over this period. Darnell Smith's development of the use of copper carbonate powder in

controlling bunt was of material benefit to the wheat industry, while Angell's discovery of the control of blue mould in seedling tobacco beds was of importance to that industry. Much useful work was conducted in clarifying the life history of pests and in adapting methods developed overseas for their control in Australia. A programme of biological control of pests was initiated, and in 1920, achieved fame in introducing the *Cactoblastis* grub to overcome prickly pear. Although the spectacular success of that first venture was not repeated, this aspect of work has yielded a number of partial successes and it has always played a prominent part in entomological studies.

Animal research during this second period was directed chiefly to a study of the aetiology of diseases of sheep and cattle and development of effective methods of control. Outstanding success was obtained in prevention of black disease of sheep by development of a vaccine and control of the liver fluke with which this disease is associated, by administration of carbon tetrachloride. Vaccines as effective agents against enterotoxaemia in sheep and pleuro-pneumonia in cattle were also developed. Control of foot rot and other diseases in sheep was also obtained. Associated with the work on micro-elements in plants, equally outstanding research was conducted in demonstrating the part played by cobalt in Enzootic Marasmus in Western Australia and Renmark Disease in cattle and of copper and cobalt in Coast Disease in South Australia.

The period from 1940 to the present

The Japanese attack on Pearl Harbour and the development of the war in the Pacific area served to clarify one very important factor, viz., that whether in peace or war, Australia's primary role is the supply of food for ourselves and the peoples of the world. With the pressure to increase production, the development of the research programme has been greatly stimulated not only in maintaining the older lines of agricultural research, but also in developing many fresh lines of attack.

Soils

With the opening up of new settlements, the need for preceding settlement by adequate soil survey to avoid the failures of the past was recognised. This period has seen a marked expansion of the research on the use of micro-element nutrients in our areas of higher rainfall. The development of the Ninety-Mile plain in the south-east of South Australia by the use of copper and zinc, the discovery of the deficiency of molybdenum in establishing sub-clover over wide areas of southern Australia, the lack of copper and zinc in extensive areas of south-west Western Australia, and the more recent work in demonstrating the role of sulphur in stimulating plant growth in the southern tablelands of New South Wales, are all examples of the great importance of research in this field.

With the clear evidence of declining fertility in our older cultivated areas there has been much activity related to studies on soil fertility and the basic studies of the physical structure of soils. Considerable attention is now being directed to the chemical studies of availability of nutrients and the base exchange complex. A start has also been made on the most important field of the part micro-biological organisms play in the soil.

This work on fertility is being closely linked with the more applied aspects of better rotational systems in maintaining fertility of our cropping areas, and in the adaptation of cereal cultivation by inclusion of a pasture in the rotation. In our better rainfall districts, it has been demonstrated that great significance attaches to the development of ley farming with considerable benefit not only to soil fertility, but also to the yield and quality of the cereal as well.

Plants

Increasing attention is being directed to crops other than cereals. The demands of the United States armed forces and advice of their experts stimulated much fertilizer and cultural work on vegetables and horticultural crops generally. The work is continuing and endeavours are being made to breed varieties more directly suited to our conditions of length of day and rainfall.

The recognition that the major potential for increased production in the future must lie in Queensland and northern Australia has directed attention to tropical and semi-tropical crops. The development of strains of hybrid maize for Queensland and northern New South Wales districts will mean much in increased production of that grain in the north. The research work initiated earlier for the sugar industry has been equally of the greatest significance in producing appropriate strains of high quality and with resistance to disease.

Much has been done to produce pasture species, such as *Paspalum dilatatum, Paspalum scrobiculatum* and Rhodes grass suited to the better rainfall regions of the semi-tropics. Several legumes have shown promise, such as Stylo, Townsville lucerne and *Phaseolus* sp., but the "sub-clover" of the tropics has yet to be found.

Northern Australia, and, in particular, the Northern Territory and north-west of Western Australia are still almost an open book, but reconnaissance surveys of potential land use based on observation of the soils and vegetation are proving a most useful tool in pointing the way for future developments. Initial investigations of potential crops are now being developed.

Pests

Wartime research has been most useful in developing more powerful and more specific insecticides, such as DDT and gammexane.

Of considerable significance in the study of the control of insect pests is the basic work initiated comparatively recently concerning growth and behaviour of insect populations when subjected to varied environments. It has now been established that, contrary to previous belief, a given insect population will oscillate widely in numbers from one generation to another when subject to a constant environment in which a limited food supply is supplied at a constant rate. Investigations are proceeding to provide basic data on the causes and nature of population variations in general.

An outstanding event of great practical and theoretical significance has followed the revival of the endeavours to control the major Australian pest, the rabbit, by means of the virus disease Myxomatosis. The sudden spread of the disease in 1951 from a test site near Corowa, New South Wales, to cover in a few weeks an area embracing the Murray River system and extending for nearly 1,000 miles from east to west and north to south provides a unique example of the use of disease spread artificially to control an animal pest. The fact that the disease overwintered and spread still further in 1952 and during the two seasons must have destroyed upwards of 100 to 150 million rabbits is of great potential significance in the drive for increased food production in this country.

Animals

A factor of major importance in the field of animal studies during these years was the provision of moneys for research under the Wool Use Promotion Act. This finance was responsible for considerable stimulation of work begun a few years previously in the fields of animal nutrition and wool production and biology. This period then has been characterized by a concentration on animal production in contrast to the previous phase of investigation of diseases of bacteriological or parasitological origin. The material improvement in pastures has brought in

its train certain problems associated with consumption of high protein pasturage which has opened up a most interesting field of scientific research on what may be termed nutritional diseases such as toxaemic jaundice, sheep infertility and dystocia. Basic genetic studies of breed and strain differences in sheep, in relation to their physiological growth characteristics, their reaction to varying environment and their capacity and method of producing wool, will undoubtedly provide for the first time a knowledge and understanding of why the Australian merino is so effective in fine-wool production and may provide the lead to further improvement in the breed.

Preliminary studies on fat lamb production have received some attention and tests of the efficiency of various breed crosses have been conducted, but the basic research has yet to be undertaken.

Cattle production, whether for beef or for dairying, has likewise not received any considerable attention from a research aspect. As in the early stages of the sheep programme, greatest attention has been paid so far to disease control and effective vaccines against contagious abortion and pleuro-pneumonia and methods for the control of certain forms of mastitis have been developed. The industry, particularly in northern Australia, has benefited from work in control of insect pests with the newer insecticides. Dairy cattle nutrition is now receiving some attention and milk production is improving as a result of better nutrition and selection on the basis of herd testing, but generally speaking, research in both dairy and beef cattle production leaves much to be desired.

Economics

The need for expansion of food production during the war years with introduction of various artificial stimuli and controls brought with it a demand for economic studies of production trends and costs of production. This work has been stimulated by the establishment of appropriate sections in Commonwealth and some State Departments. Much of the work has been directed so far to collection of data and development of satisfactory techniques. Surveys have also been initiated in the field of social studies in rural communities.

IMPORTANT FIELDS OF RESEARCH FOR THE FUTURE

We have seen over the years the gradual improvement in both plant and animal production as a result of investigation and research. Broadly speaking, development has followed similar lines in each field of primary production. Initially farmers or graziers applied methods of production developed overseas to Australian conditions and research was directed mainly to the control of diseases and obvious nutritional deficiencies. As a more basic understanding of the reaction between plant or animal and the environment was obtained, so it was possible then to plan a programme of adaptation of variety or strain to the environment here and to modify the method of production to meet our specific needs.

Plants

Turning to specific fields, the development of research on wheat production presents a pattern which can well be directly followed for other cereals and crops, to which only moderate attention has been paid so far. Production of varieties of wheat suited not only to the general Australian environment, but to that of specific districts has been most successful with the result that further increases in yield of wheat will be increasingly harder to obtain. Further attention to specific characters, such as drought resistance, quality and disease resistance (in particular, rust) is desirable, but additional basic research on inheritance of these characters will be essential before we can achieve full success. With cross-fertilized cereals, we have made a start in utilizing hybrid vigour in increasing maize yields but much remains yet to be done both with this crop and with other cross-fertilized species.

Our programme of pasture research has yielded outstanding results in southern Australia in the past twenty years in the selection of the best strains and mixtures of legumes and grass species and in providing the necessary macro and micro elements for their adequate nutrition. Much remains yet to be done in the production of new improved strains by hybridization and the application of genetic principles is almost an open field.

The realization that pastures are a dynamic mixture of a number of species of grasses and clovers in which dominance of one or other varies from time to time with altering management and fertilization has resulted in recent years in the need for research in pasture ecology. Much basic research, linked with experimental work in this most important field, will be necessary in the future.

Extension of the work to northern Australia has been started. The production of adequate pastures in the north is immeasurably more difficult than in the south. Not only are many of the soils themselves low in fertility, but the rapid growth of pastures, when rainfall and temperature are favourable, results in production of fodder of such low protein that stock fail to thrive on normal dry pastures for many months of the year. Nitrogen shortage then is the main problem of soils, plants and animals and intensive research will be necessary before this problem can be solved. The search for a pioneer legume to do for the north what subterranean clover has done for the south must be pursued in the most thorough manner possible. It may be, however, that the solution must be sought in ways other than this. Chemical and bacterial activity are greatly stimulated by the higher temperatures and humidity of the north and the general picture in the south of building up organic matter and with it nitrogen may have to be radically changed. Basic physiological and microbiological studies under tropical and semi-tropical conditions will play an important part in providing the key.

In the field of horticulture, much work remains to be done in the production of suitable strains and varieties and in the applied fields of fertilizer and cultural treatments and orchard management. Proper understanding of bud initiation and development of flower and fruit and of nutrition and storage is more essential in these perennial woody plants than in annual crops.

Australia has been fortunate indeed in the plants such as subterranean clover which have been introduced from overseas, in many cases accidentally. Greater time and thought is now being given to a planned programme of plant introduction on the basis of bioclimatic zones, but a start only has been made. Much additional work remains to be done in developing effective climatic indexes and in obtaining the necessary environmental data in Australia and overseas.

Soils

Underlying and basic to the development of crop, pasture and tree is the soil and a far better knowledge of what we mean by soil fertility is a major problem of the future. Soil surveys and their classification must first be available before we can hope to utilize soils to the best advantage. Man must then use the soil, must cultivate it, draw on its reserves and alter its structure by cropping. More intensive basic studies on the physical and chemical structure of soils and of water movement in soils are essential before we can understand what is involved in maintaining soil fertility. We are realizing also to a greater degree than before the importance of the organic content of the soil and the significance of the microflora in affecting soil structure and availability of plant nutrients. This is a field that will open up much information on our problem of fertility.

Animals

Research in the field of animal nutrition and breeding will be of the greatest importance in the next ten years. The immediate programme for sheep and wool production is already under way.

Basic physiological and biochemical studies of the processes of nutrition in the ruminant and the metabolic stages in production of carbohydrates, fats and protein will give valuable information. Detailed research on the inheritance of genetic factors controlling growth of sheep and production of wool and their reaction to varying environment will do much to supply the information necessary for the breeding of improved strains of sheep, while physiological studies of reproduction in rams and ewes and pre- and post-natal mortality of lambs will reduce losses and aid in increasing flock numbers.

A world protein shortage, however, is likely to be a major factor for many years to come, and greater attention, both to fat lambs and beef cattle, is essential. Much of the information arising from the sheep and wool programme will be of value as far as fat lambs are concerned, although the work will have to be extended to breeds other than the merino. The need for such studies is all the greater since pastures and sheep are playing such an increasing and valuable part in our cropping areas.

Intensive research on both beef and dairy cattle has been comparatively neglected to date. Overseas investigation will undoubtedly be of considerable value for our more favoured temperate regions, but detailed work is necessary under our environmental conditions. However, the development of northern Australia, which must depend on cattle rather than sheep, necessitates a real pioneer effort on the part of Australian research workers. The problems of an unfavourable environment, low protein pastures and greater activity on the part of pests generally accompanied by the economic handicaps of large properties, long haulage and distant markets all add to the difficulty of the situation. The general outline of the programme is clear enough—improved nutrition, production of new breeds to withstand the environment (and here we will have to look for strains evolved in overseas tropical countries) and improved management of stations and herds—but money, and, more important, trained men will be needed in large quantities.

Pests

Development in weed and pest control will undoubtedly result in many new discoveries in the next ten years. The extensive programme and thorough manner in which large overseas commercial interests are undertaking the search for new and more effective weedicides and insecticides will aid us materially in reducing production losses. The trend to replace more general poisons with chemicals having a very specific effect will bring with it a more fundamental problem since with each new specific treatment, a race of resistant insects tends to develop and the process of control may be never ending.

It is on the general problem of insect pest control and host-parasite relationships that we may need a new outlook in the near future. Insecticidal and fungicidal sprays are said to be improved each year with more effective chemicals and yet there appears to be no diminution in the insect population or reduction in the spray treatments necessary. The population dynamics studies may supply the answer as to why when a new control measure is introduced it often achieves spectacular results initially, but the good results are not always maintained over a period of years. Temporary partial control, by reducing parasite numbers and increasing the food or host potential, may result actually in an increase in the next generation and reverse the effect we desire to obtain.

Studies on the myxomatosis epizootic may also open up interesting new avenues of research not only in the study of the mode of action and method of dispersal of the virus by the several responsible vectors, but also on the general problem of the most effective method of utilizing the disease in controlling the rabbit. Of great potential significance also is the study of the immune remnant population remaining after the disease has had a major kill.

Economics

Since the war there has been some development of research in agricultural economics. There is a need for much more work in this field and it would appear that two conditions must be satisfied before economic research into agricultural problems becomes fully effective. The first is that governments should be convinced that economists need to be granted the same freedom as other agricultural investigators to undertake long-term fundamental investigations. The second is that economists should, themselves, be willing to accept the discipline of careful and painstaking, long-term studies. The basic information about the economic problems of Australian agriculture will not be obtained any more quickly or with any less effort or expense than data on the more direct biological problems.

ORGANIZATION AND FINANCE

A review of the organizations and institutions conducting agricultural research in Australia has been presented recently (Commonwealth Agricultural Bureau, 1952) and there is little point in repeating the information in this paper. A list of the detailed research projects kindly supplied by the three groups of research bodies, the Commonwealth Scientific and Industrial Research Organization, the State Departments of Agriculture and the various State Universities, has been recorded in a separate document which has been lodged for reference at the Head Office Library of the first-named.

Organization

From the research point of view, speaking generally, there is a tacit agreement whereby the Commonwealth organization concentrates primarily on basic research problems pertaining to broad regions, whereas State departments look chiefly to the applied problems and investigational work associated with specific local districts. The Commonwealth organization has the added responsibility of conducting research in the physical and chemical sciences and State departments are responsible also for extension and regulatory functions within their boundaries.

In maintaining and developing its research programme covering not only the solution of immediate problems of agriculture, but also the long-range basic research, the Commonwealth organization owes much to the absence of direct political and public service control and to its freedom to encourage originality and individuality in its research officers.

Apart from the Waite Agricultural Research Institute of the University of Adelaide, conduct of biological research in the Universities has not been adequately developed in Australia in the past although increasing attention is now being given to this phase of university activity. If the necessary finance could be obtained and outstanding research leaders were available, the Universities would have much to gain from a closer linkage between teaching and fundamental research.

Much good would result from closer contact between workers of these three groups not only in linking the research programmes and in facilitating the application of research findings, but equally in ensuring that the production problems facing industry are recognized by research workers. Although it was envisaged originally in 1926 that the Standing Committee on Agriculture would perform this function as far as the State Departments of Agriculture and the then Council for Scientific and Industrial Research were concerned, in recent years the difficult problems associated with stimulation of the food production programme have occupied the committee's attention to a greater and greater degree. It may well be that the time is opportune, therefore, to consider the setting up of an Agricultural Research Council as Great Britain has done, with the best scientific brains available in the country and with adequate financial resources to plan and support agricultural research investiga-

tions in Australia. As Sir William Slater has stated in a recent article (Slater, 1951)—"To fulfil (its function) the Council must survey continuously the whole field of agricultural research and try to assess the effort which is being put into each part". "Thus the A.R.C. . . . relies on the research workers themselves to plan an integrated programme orientated towards the solution of the more important problems of farming, and not on any central organization or direction; however, it reserves its own funds to encourage and support work which it believes to be important, but which has not found a place in the programmes of the research institutes."

Shortage of trained research men of top calibre is the biggest handicap to advancement of research in Australia at the moment, and the numbers of undergraduate students in the biological fields, far from showing any increase, appear to be falling, and will certainly not meet the demands of the future. Some welcome relief has been forthcoming from overseas graduate workers who desire to emigrate to Australia, but a solution to the main problem of attracting undergraduates to biological research must be found.

Finance

It is difficult to get any accurate figure of the finance which is made available for agricultural research in Australia since so much of the activities of officers of State departments is jointly extension and investigation, and similarly in the case of the Universities, research is linked with teaching.

However, a survey was made and approximate figures for expenditure in 1951/52 on agricultural research and investigational work (excluding capital works expenditure) have been kindly supplied by the various Departments and Universities. Summarizing these under three groups, the figures are as follows:—

Commonwealth, including C.S.I.R.O. and the Bureau of Agricultural Economics—£1,450,000.

State Departments, including Agriculture, Conservation and Irrigation—£780,000.

State Universities—£170,000.

Total—£2,400,000.

Private industry also is conducting some research in particular fields, chiefly of pest and disease control, and primary producers' organizations contribute, to some degree, to the work of the government departments, but it is not possible to get any estimate of these figures.

The estimated figure for total value of rural production for Australia has risen materially in recent years from an average figure of £320,000,000 for the ten years 1938/39 to 1947/48 to £640,000,000 for 1949/50 and £1,007,000,000 for 1950/51. The material increase in the latter figure was due to the abnormally high wool values obtained that year, so that the 1951/52 figure is likely to be well below this figure. The expenditure on research, therefore, is of the order of between 0.3 and 0.35 per cent. of the total value of production.

The figures for expenditure on agricultural research in other countries provide some interesting comparisons. P. V. Cardon (1952), estimates the figure for the United States, including both federal and state expenditure, at 106 million dollars. To this must be added the expenditure on agricultural research conducted by Universities, but a large proportion of this is financed by either federal or state grants. With total United States rural production at about 28,000 million dollars, agricultural research is, therefore, of the order of 0.4 per cent., but private industry undertakes quite an active research programme in America.

Agricultural research is undertaken by three groups of bodies in the United Kingdom—the Ministries of Agriculture in England and Scotland, the Agricultural Research Council and the various universities. The estimated total of agricultural research expenditure by these for 1951/52 amounts to over £4m.stg. for a total rural production of some

£900,000,000. This represents between 0.4 and 0.5 per cent. of rural production. Private industry also conducts extensive research investigations in Great Britain. Can Australia, with its wide diversity of environment and crops and its many new problems afford to spend less proportionately on its research programme than England?

It has been the general custom in the past, not only in Australia, to expect governmental institutions to bear practically the whole cost of research and investigational work for the primary industries. While the numerous resolutions that are passed annually by producer organizations show, no doubt, an appreciation of the benefits that are to be obtained from research, the burden of providing the finance if all demands are to be met, will lie heavily on the taxpayer. In the earlier stages of development with small producers and heavy capital expenditures, government support for research is justified, but with the present growth of expenditure it appears warranted to expect producers themselves to play a larger part in the work, not only in providing part of the finances, but in the thought, time and energy involved in the direction of the applied part of the research programme.

Producers overseas are showing increased interest in research work and in developing and contributing to that work are themselves benefiting by better knowledge of research and quicker application of results.

In Australia also, producers are showing a much keener interest in research, although few are, as yet, making an appreciable direct financial contribution except as general taxpayers to the conduct of the work which benefits them so materially. As one example, farmers in the Murrumbidgee Irrigation Area, New South Wales, have joined with the State Departments, the Rural Bank and Commonwealth Scientific and Industrial Research Organization in contributing finance to set up an Irrigation Research and Extension Committee which, in addition to supporting its own extension service, also plays a part in co-ordinating the research activities of the various organizations in the district.

An interesting example is afforded also by the Queensland Bureau of Sugar Experiment Stations. Started initially some fifty years ago by the Queensland Department of Agriculture and Stock, this service now employs some twenty-five trained scientists, covering general agronomy, plant breeding, pathology and entomology in addition to mill technologists, and completely services the whole sugar industry in that state. Financed originally by the Queensland government, an act was passed in 1900 whereby the industry then contributed for the research activities on a pound-for-pound basis with the government, and an advisory committee of representatives of the government, the millers and cane-growers was set up. As the activities grew and growers appreciated the benefits, so the industry, by means of levies, increased its proportion of the grant. Expenditure of the bureau rose to £63,000 by 1951/52, the state's normal production of sugar cane being approximately 900,000 tons with a value of about £25,000,000. The most recent amendment to the act provides that control of the bureau is passed entirely to the committee and the Director of the Bureau, and whereas the government grant is retained at the 1934 figure of £7,000 p.a., the contribution of the industry may rise to over £100,000. The material benefits that have resulted from this most effective joint co-operative effort may well merit careful examination by other rural industries.

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THE SUGAR INDUSTRY IN AUSTRALIA

By L. G. VALLANCE

Introduction

The Australian sugar industry is restricted entirely to the production of cane sugar. In the world picture Australia ranks fairly high as a producer of this commodity and normally occupies fifth or sixth place in tonnage output. The annual world manufacture of cane sugar is about 20 to 22 million tons, obtained mainly from some 35 countries.* Of these, Cuba is by far the greatest contributor with a production frequently reaching close to six million tons. Three other countries, viz., India (with Pakistan), Brazil and Puerto Rico, consistently produce between one and two million tons each, while Australia may be bracketed with the Philippines, Hawaii and the British West Indies with a production within the range 800,000 to 1,000,000 tons annually. In 1939 Australia produced 928,000 tons (raw sugar 94 n.t.), but, with the advent of war, the production dropped sharply to 524,000 tons in 1943. Post-war difficulties and shortages of equipment, fertilizers and manpower made the return to normal a slow process, but by 1948 the crop yielded 943,000 tons. At the present time, in view of the assured market created by the recent export agreement with the United Kingdom, Australia's production to be reached by 1953 has been set at 1,100,000 tons of raw sugar and 1,207,600 by 1954-1955.

Development of the industry

Location of crops

Although the planting of cane was recorded in New South Wales as early as 1823 it was not until the 1860's that any known commercial developments occurred. As might be expected the movement of these ventures was northward towards the warmer and more humid areas, and by the turn of the century, cane growing had spread throughout the subtropical and tropical coast of Queensland as far as Mossman in Cape York Peninsula. This centre still forms the northernmost boundary of the industry, which now extends over a narrow strip some 1,300 miles in length, between 16° and 30° south latitude. The majority of this land lies within 20 miles of the sea and only in very few instances is any cane grown more than 40 miles from the coast.

Considerable variations in rainfall and temperature occur over this elongated area and these bring about important cultural and varietal differences in the management of the crop. Queensland produces 95 per cent. of the output, the remainder coming from the northern rivers districts of New South Wales.

Labour and economic problems

The development of the industry has been largely influenced, even from infancy, by labour requirements and economic considerations. At the outset, during the pioneering era, the plantation system was predominant and many of these comparatively large holdings operated their own crushing and processing plants, while others merely crushed the cane and piped the juice to a central factory. A feature of the plantation management was the use of coloured Polynesian labour, and as the plantations expanded so the recruitment from the South Sea Islands was increased, until it became necessary for the Queensland Government to intervene with a series of acts designed to control the whole system of in-

*The world's beet sugar production is approximately half that of cane sugar.

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dentured labour for the benefit of both employer and employee.

During this period (i.e., prior to Federation, and indeed for many subsequent years) Australia grew only a small proportion of her total sugar requirements and therefore a considerable amount of sugar was imported, with which the locally-produced article had to compete. Each of the colonies operated its own tariff schedules and there is little evidence to indicate any preference to sugar grown in Queensland or New South Wales.

Nevertheless, the industry held its own reasonably well until the middle eighties, when importations of European beet sugar depressed the available market. Germany and other European countries were rapidly developing and expanding their beet industries, and were showing great interest in acquiring an export market. These exports were bounty fed and the large quantities arriving in Australia had a disastrous effect on the industry. At a London meeting the president of the Colonial Bank remarked that sugar had reached a price at which it could not be profitably produced in any part of the world. It is of interest to note that, from the beginning, the well-being of the Australian sugar industry has been intimately connected with international sugar production, a position which has persisted and is of paramount importance at the present time.

The low prices which prevailed for the next few years resulted in many plantation and mill owners leaving the industry, and with the cutting up of large estates, the plantation system began to give way to small holdings. The smaller and more inefficient mills disappeared and the trend towards central mills supplied by surrounding growers became more pronounced. This latter movement was fostered by the Queensland Government which made money available for the erection of efficient units capable of treating substantial quantities of cane. A further blow to the plantation system was "The Pacific Islanders Act of 1885" which legislated for the cessation by 1890 of the importation of island labour. This was not implemented because of a change of government, but with the coming of Federation, the first act relating to the sugar industry passed by the new Commonwealth Government provided for the restriction and subsequent prohibition of this source of labour. For social reasons many Australians, particularly those in the southern colonies, regarded the Kanaka population, which was building up in Queensland, with dislike and suspicion. It was therefore with mixed feelings that the sugar industry approached the question of Federation, since it was known that, on the one hand, all coloured labour would disappear but that on the other, free entry to Australian markets would be gained.

To encourage and hasten the production of sugar by white labour only, the Commonwealth passed the Excise Tariff Act of 1902, which imposed an excise of £3 per ton with a rebate of £2 per ton for sugar produced solely by white labour. Three years later the excise was raised to £4 per ton, whilst the rebate was abolished and replaced by a sugar bounty of £3 per ton on white-grown sugar. Naturally enough, this drastically affected the labour position and by 1906 the change to the white settler, each working his own small farm with a minimum of employed labour, was practically complete. In 1913 the excise and bounty were abolished, and with it was removed the misunderstanding prevalent in southern states that the Commonwealth Government was subsidising the sugar industry. Actually, of course, as the above figures indicate, there was nothing to support the view that the industry was being fostered at the expense of the other states; in actual fact support of the White Australia policy cost the average Queensland grower £1 per ton of sugar, and it is estimated that nearly £3 million

went into commonwealth revenue during that period.

Development of export trade

By the beginning of World War I Australian sugar production had approached the quarter million tons mark but it was not until 1924-25 that it was necessary to seek an export market to dispose of substantial amounts of surplus sugar. During the war the Commonwealth Government placed an embargo on the export of sugar since Australian consumption was still greater than its production, and at the same time fixed the price of raw sugar so that it varied during the war from £14 to £21 per ton, although the average import price for raw sugar was about £40 per ton. Soaring production costs, together with war-time and post-war difficulties beset the industry, and in 1920, after reviewing the position, an agreement with the Commonwealth Government increased the price to £30/6/8 per ton. The effect of this sugar agreement was far-reaching, and although it was revised in 1923 and the price reduced to £27 per ton, the impetus given to the industry resulted in a considerably increased production.

In disposing of its product the industry was soon presented with a problem that was a complete reversal of its previous difficulties. By 1925 it faced its international competitors as an exporter rather than as a defender of its own home markets. However, times were adverse for the sale of surplus sugar since world prices were low, and moreover the southern states were exerting pressure on the Commonwealth Government to lift the embargo and allow the importation of cheap foreign sugar. In 1930, Queensland pressed for the renewal of the embargo, but, in the face of considerable opposition, the Government hesitated and finally appointed the Commonwealth Sugar Enquiry Committee with a wide commission to enquire into the affairs of the sugar industry. In looking back it is evident that this enquiry was a particularly fateful one and the committee's recommendation (which was accepted) for a continuation of the embargo, together with the principle of price stabilisation by negotiation between the Queensland and Commonwealth Governments, was a milestone in the history of the industry. It is of interest to note that it was this committee also, which recommended that concessions by the sugar interests to the Australian fruit industry be in the form of an annual sum (initially £315,000). This concession continued until 1951, when, in consideration of the fact that the Fruit Industry Concession Committee Fund had accumulated a surplus of over £1,000,000, it was agreed to withhold further payment until the fund had dropped to half a million pounds.

The retention of the embargo was not popular in many quarters but the enquiry committee represented a diversity of interests and its adoption of a national outlook paid dividends in the years that followed. World prices increased and in ten years Australia was producing sugar more cheaply than it could be imported. The latest official review* indicates that since 1923 the Australian consumer has saved over £63,000,000 (including duty) by being able to purchase sugar at the fixed home consumption price as compared with the landed cost of the cheapest available import sugar. Actually, it must be conceded also that the national gain is far greater than the above amount, since the Australian consumer and manufacturer have been kept well supplied in spite of the acute world shortage occasioned by World War II and the severe and continuing deficit of sterling sugar.

*Statement supplied by industry to 1952 Sugar Price Enquiry Committee. It may be of interest also to quote the following figures from the same authority: (a) In the past five years (1947-1951), the net export earnings, after deducting marketing costs, freight, etc., have closely approached £37½ million pounds and (b) 1951-1952, average net price of Australian refined sugar to wholesalers and manufacturers—£55/0/3 per ton; average landed cost of cheapest available refined sugar—£88/5/4 per ton (includes duty £9/6/8 per ton).

Control of production

The large potential for production in Queensland, together with the fact that markets were neither unlimited nor particularly favourable to sugar produced under Australian living standards, engendered the early realisation that rigid methods of production control were necessary. The Sugar Acquisition Act of 1915, by means of which the Queensland Government acquires the whole production and disposes of it at a price fixed by negotiation with the Commonwealth Government, brings the marketing of the year's production under the one body—namely, the Sugar Board. This board has both government and industry representation. Because of its responsibilities in this respect the State Government finds it necessary to control by legislation the supply of cane from grower to miller with regard to price, conditions and time of delivery, the defining of areas supplying each mill, and many other related factors. Two most important features of these controls are the fixation of "sugar peaks" and the administration of the "assignment system", both of which impose a tight restriction of production.

The Sugar Peak Scheme

As previously mentioned, from 1925 onwards, it became increasingly apparent that a substantial quantity of surplus sugar would have to be exported. To stabilise the position the industry, in addition to seeking the Commonwealth's help by means of import embargo and price negotiation, introduced (through the State Government) legislation to impose a strict limitation on the amount of raw sugar that any mill could produce for disposal at the current overall price. This stipulates that sugar produced above the "peak" be declared excess sugar, and as such its disposal depends entirely on the export market, which, at that time, was most unattractive. The summation of these "mill peaks" in turn represents the state's maximum production in this respect. The first peak was set in 1929 at 611,428 tons and this has been increased at intervals as follows:—1939, 737,000 tons; 1949, 848,600 tons; 1950, 916,900 tons; 1952, 963,080 tons, and 1954-55, 1,162,600 tons. These figures refer to Queensland production and do not include the relatively small contribution (45,000-50,000 tons) of New South Wales.

Important factors in these increases were expanding home consumption and, latterly, the trend towards better overseas markets; the latest increases being closely linked with the present deficit of sterling sugar and a consequent export quota safely covered by guarantee under the recent export agreement with the United Kingdom.

The restriction imposed upon each mill insofar as its quota of manufactured sugar is concerned, i.e., its "peak", is ultimately passed on to the individual farmer, usually as a "farm peak". By this means the production of each farm is limited, either in terms of tons of cane, tons of sugar, or acreage which may be harvested. As might be expected, the resale value of a cane farm depends largely upon its peak or assigned acreage. Undoubtedly such a control makes for steadiness in farm values, and in consequence, for a stable and well-established farming community. It is also an incentive to efficiency, since the more economically a grower can produce his peak the greater will be his profits, provided, of course, that it is sufficient for a reasonable standard of living. Obviously, as production costs rise due to increases in labour, fertilizer, equipment and other expenses, so the value of a particular peak decreases unless there is a simultaneous and equivalent increase in the price of sugar. Therefore, a peak which is too small will be the first to fall below the threshold of standard living conditions. This factor is of some concern to the industry.

The equitable distribution and adjustment of peaks is administered under the

Regulation of Cane Prices Acts, and governmental, technical, grower and miller representation is provided for. The whole system of control is so intimately bound up with the economics of the industry that there are probably very few other crops in which production costs have been so minutely and extensively recorded in relation to monetary returns.

The Assignment System

The assignment system has provoked considerable comment from various sources, mainly outside the industry. This statutory control prohibits, in effect, the growing of cane for milling on any land other than that which has been allocated or assigned for that purpose. Such measures are designed to co-ordinate the relations between miller and grower, i.e. the former has an assured and known supply of raw material for processing, since the farmer may only supply to the mill to which his land is assigned, while the grower has the security of an outlet for his crop, since the miller must accept suitable cane at award prices. It also contributes to the smooth working of the many domestic arrangements necessary between the farm and the factory. Furthermore, because the acreage of assigned land cannot be altered or increased except by regulation the system functions as a very powerful instrument of crop limitation. Insofar as these important considerations are concerned there is no doubt of its desirability and no responsible section of the industry would press for its removal.

A criticism that the system attracts is the accusation that it promotes monoculture with its alleged (and sometimes very real) attendant evils. However, it is not so well known that the grower may harvest only 75 per cent. of his gross assigned area in any year. This automatically imposes a fallow period of nine to twelve months in each four-yearly period, which is the average length of a crop cycle between planting and replanting. The almost universal practice of green manuring with legumes during the fallow renders the term monoculture not particularly applicable.

The industry has not complacently accepted its one-crop economy, but there is little evidence from the many investigations to show that sugar soils are deteriorating. If such is the case it is not reflected in yields, which have shown marked increases and are still improving. Whether these increases should have been greater in view of modern scientific methods is, in the light of present knowledge, an unanswerable question. To amplify crop rotation and still maintain the present rate of production would involve an immense expansion of acreages, tramways, irrigation works and innumerable other things. Even if this were possible it would be difficult to prove that it would be justifiable.

It is a fact that every other major sugar producing country (Java excepted) has built up the same intensive concentration of areas in more or less continuous production, and this has happened because of convenience or natural limitation of land, not from any statutory definition of assigned lands. The agricultural methods, the climatic and economic conditions of these overseas areas have been studied at length and at frequent intervals, and it is somewhat reassuring to know that many of them have been producing cane for several hundred years longer that their counterparts in this country, without any indication of yield diminution. It may well be that sugar cane, with its four- or five-year crop cycle and its excellent soil protecting canopy, is a crop which helps to maintain soil fertility. A point to be realised is that the huge volume of stubble and roots and the large amount of unburnt trash and tops return to the soil plant residues rich in sugars. These undoubtedly help to provide a favourable environment for the soil microbial population.

Research and technical progress

It should not be thought that the only difficulties with which the industry has had to contend were those of price and marketing. At several periods it has been severely affected, and indeed threatened with utter disaster, by outbreaks of plant diseases. From time to time bad infestations of pests have practically decimated the crop in the far north, while the deterioration or "running out" of favoured varieties and the necessity for replenishing plant foods have been urgent problems. In order to make itself as technically efficient as possible, the industry spends considerable sums of money annually on investigational and advisory work.

The Bureau of Sugar Experiment Stations was first instituted in 1900 and has functioned on an increasing scale since that date. At the present time it employs some 40 technical officers who are stationed either at the central laboratories in Brisbane or at the many experiment stations and sub-stations located in the major sugar-producing districts. All aspects of agricultural importance have received attention since the beginning of the century, while mill technological investigations have been carried out for the past 24 years. In addition, the Sugar Research Institute has been recently formed to supplement research into milling problems and the utilisation of by-products. In most mill areas, local Cane Pest and Disease Control Boards operating under the Sugar Experiment Stations Acts employ supervisors, inspection and roguing gangs to deal with pest and disease problems on the spot. The majority of the proprietary mill-owning companies maintain well-equipped laboratories and undertake both agricultural and manufacturing research. A notable case in point is the cane-breeding nurseries of the Colonial Sugar Refining Co., which have produced varieties of great importance to the industry.

Except for a very small governmental grant, the industry maintains the Bureau of Sugar Experiment Stations by means of a levy imposed per ton of cane crushed, paid equally by millers and growers. The other organisations are financed solely by the industry. The present annual expenditure of the bureau alone is over £100,000, but there is no doubt that the money spent over the years has been returned many times over.

Cane breeding has been a particularly important phase of its activities (some 20 to 30 thousand new canes are bred every year) and the introduction of new varieties has been of utmost importance in all areas since this work commenced thirty years ago. Because of their vigour and disease resistance, wild canes such as *Saccharum spontaneum, S. berberi* and *S. robustum* are crossed with the sweeter but less hardy noble varieties *S. officinarum.* In the early 1930's over 70 per cent. of the varieties used were purely noble canes, but so great has been the varietal revolution that these have been largely supplanted by wild-blooded types and today represent only about 20 per cent. of the crop. In the southern and central districts the change-over is practically complete, but in the north the purely noble Badila is still an important variety. It is interesting to note that, although the tropics are considered to be the natural habitat of sugar cane, the plant breeder has produced hybrids that allow the colder, sub-tropical southern areas to enjoy a greater average tonnage per acre than the far north, which is some 600 miles north of the tropic of Capricorn.

Stringent control measures and the use of resistant or tolerant varieties have reduced the toll of previously devastating diseases to negligible proportions, and this has enabled work to be concentrated on those of a less spectacular nature, which, because of their very insidiousness, are felt to be the cause of hitherto unknown losses.

The "greyback" grub *Dermolepida albohirtum* (Waterh.) has, in the past, been responsible for a great deal of damage, particularly in the northern areas where surveys have indicated that seasonal losses of over 100,000 tons of cane were a common occurrence. This pest has now been efficiently and economically controlled by the use of benzene hexachloride. The solving of this problem alone has been worth more to the industry than its total expenditure on research.

The development of soil analytical methods in conjunction with fertilizer trials and fertility surveys has been an important factor in enabling the industry to make effective use of fertilizers. The sugar soils are, with few exceptions, very poor in plant food content and the average annual application is about four cwt. per acre of mixed fertilizer (N.P.K.) plus one to two cwt. of sulphate of ammonia as a top dressing.

Perhaps the results of the industry's insistence on a vigorous research policy may be best summed up by quoting average yields of sugar per acre for the following ten-yearly periods:—

1870-1880—1.27 tons
1880-1890—1.69 tons
1890-1900—1.28 tons
1900-1910—2.23 tons
1910-1920—1.88 tons
1920-1930—2.33 tons
1930-1940—2.88 tons
1940-1950—3.42 tons

The milling side of the industry has also profited from investigational work, and fundamental processes such as juice clarification and sugar boiling have been raised from a "mysterious and secretive art" to control by the potentiometer and microscope.

Efficiency and some problems

Recovery figures insofar as sugar per acre per month is concerned compare very favourably with those of other countries, as is indicated below.*

Louisiana and Florida—320 lb. sugar per acre per month.

Cuba—360 lb. sugar per acre per month.

Puerto Rico—480 lb. sugar per acre per month.

Queensland—560 lb. sugar per acre per month.

Hawaii (irrigated)—760 lb. sugar per acre per month.

Burdekin (North Queensland) Irrigation area—860 lb. sugar per acre per month.

Queensland leads all other major cane countries in quality ratio or sweetness and consequently a smaller tonnage of cane is required to make a ton of sugar. Cane sugar ratios vary from just above, to just below, seven tons of cane per ton of sugar according to season, as compared with nine to twelve tons in other countries. However, it must be admitted that this is not because of more successful cane breeding, better farming or more efficient extraction, but is mainly due to the dry weather conditions which normally prevail during the harvest period.

A point of some consequence is the predominance of small independent freehold farms on which the prosperity of the owner increases with his own efforts and on which the necessity to employ hired labour is reduced to a minimum. There are many advantages of such a system in comparison with the large plantations which still characterize most overseas sugar industries, particularly since mechanisation of the small farm is no longer uneconomic. Thanks to the fast-moving, high-clearance tractor of relatively low unit cost, practically all routine farm operations are carried out mechanically; the horse has disappeared. The farmer's cane is weighed and

*Statement by Director, Bureau of Sugar Experiment Stations to 1952 Sugar Price Enquiry Committee. For year 1948.

analyzed at the mill and he is paid according to its content of commercial cane sugar. This creates immediately an incentive to produce high quality cane.

Similarly, since the miller pays for cane on the basis of its recoverable sugar content it is to his advantage to attain maximum recovery by the most economic methods.

Presumably all industries have their problems and so has the sugar industry. Because of its magnitude it is inextricably bound up with world sugar, and its fundamental problem is to balance the Australian standard of living under which its product is grown and manufactured against that of its competitors. Technically, the industry is as efficient as its resources can make it, and in this respect, while there are possibly many countries that can claim equal all-round efficiency, there are very few that can claim greater. One of the industry's immediate requirements is to expand milling capacity and to bring about a more economic handling of the crop as a whole. During the war and for some time afterwards, new equipment, replacements, steel, rolling stock, etc., were all unprocurable. At the present time this situation to a large extent no longer exists, but the fantastic cost of any major undertaking prohibits all but the most essential and dividend-returning expansions or replacements. The "know how" is there but the solution of the financial problem is difficult. Nevertheless, in order to reduce transport costs and to alleviate the jute bag supply position, some millions of pounds are being spent to provide facilities for the bulk handling and shipment of raw sugar. In addition, many mills have commenced the 1952 season with new and much-wanted equipment which had been on order for two to three years.

Let us consider the fact that most cane ripens about October; before and after this time its sugar content is appreciably less. It is impossible to process the crop in less than six months, and at the beginning of the crushing, about June, the sugar in the cane may be only 60 to 75 per cent. of its maximum at maturity. Similarly, cane harvested at the end of the season is rapidly losing sugar. Many mills would undoubtedly like to increase their processing rate in order to handle the maximum amount of cane at its ripest stage, but, unfortunately, with present plant capacity such an increase would result in an appreciably lowered co-efficient of extraction and recovery of sugar from the cane. As might be imagined, the point of balance between capacity and quality is of importance and is receiving considerable attention. It has not been neglected by the cane breeders whose efforts for some time have been directed towards the introduction of both early maturing varieties and canes that hold their sugar late in the season. At the moment there are indications that the agriculturists are nearer to solving the problem than the financial experts. As revcaled by the progressive yield increases quoted previously, signs are not wanting to indicate that research in the fields, and also the factories, has enabled the industry to keep its head above the economic morass. However, there is a limit to what can be wrung from Mother Nature and it seems that the time is now ripe for some improvement in the handling of the problems that cloud the fiscal horizon.

Some social aspects

There are very few fortunes to be made in the sugar industry and the fabulously wealthy sugar "barons", if they ever existed, have disappeared. The crop is produced by 7,000 to 7,500 growers whose average output per farm was about 700 tons of cane in 1951—a poor year—and about 900 tons in 1950—which was a good year. The net return per ton of cane varies greatly according to where and when it is computed; however, for the purpose of the present article it is of interest to note that in a recent claim for price adjustment the industry considers

that the net return should be of the order of 23/- per ton of cane. As to how close this figure is approached under present conditions is not a matter for discussion here, but it is useful to indicate that, in general, the individual farm is an economic unit. There are 31 mills in Queensland and three small ones in New South Wales. Half of the former are co-operatively owned by the cane suppliers and this is an added feature of definite value in the stabilisation of a farm community. Very few sugar growers have any other source of income and it has not yet been possible to establish on the cane farm any rotational crop of significant marketable value. The industry has long realised that its "eggs are all in the one basket" and hence its policy of not stinting expenditure on organization and research.

Sugar has populated the tropical coast of Queensland and has established a large number of thriving communities, towns and cities with a network of communications by air, road and rail. It may well be that if sugar had not done this the opportunity would have been taken by some other crop or some other industry. Admittedly, in the face of past history of labour and market difficulties it is hard to visualize any alternative development. However, what is more important is to consider again the question of providing a place for these other food crops, side by side with sugar. There is still land to be developed.

(*Received for publication, October* 17, 1952).

OBSERVATIONS ON BEEF CATTLE PRODUCTION AND MARKETING IN THE UNITED STATES

By G. H. ALLEN

In the United States, which has a population of 150 million people, there are some 81 million cattle, 61 million pigs and 31 million sheep. Livestock numbers per head of population, in comparison with Australia, are:—

	Cattle	Pigs	Sheep
Australia	1.78	0.17	12.70
U.S.A.	0.54	0.40	0.20

The Census of Agriculture shows that cattle are raised on nearly five million farms and ranches, pigs on four million and sheep on over half a million. An interesting facet of animal production is that 66 per cent. of the beef cattle, sheep and pigs are produced west of the Mississippi River, while more than 66 per cent. of the meat produced is consumed east of the Mississippi.

The statistics of cattle slaughterings are significant. Some 33 million beeves (21 million cattle and 12 million calves) are turned off each year, this representing a proportion of total cattle population of 1:2.5. For Australia, the corresponding proportion is approximately 1:5. For Queensland it is 1:6, but over a quarter of a million cattle leave the state as stores or fats and are killed elsewhere. These comparisons are very important; they suggest that the production of beef in Australia may be profitably increased by quicker turn-off of market quality cattle without necessarily increasing the total number of cattle.

Beef prices and feeding costs

The movement of cattle from breeding areas to the corn belt is highly developed, due largely to the regular and exceedingly high farm production in the corn-growing states. The west coast offers a comparatively small market but there is a well-developed fattening industry on the irrigated plains of that region. More than 75 per cent. of the cattle marketed for beef come from farms and feeders, and this accounts for the high proportion of young, high-quality beasts slaughtered.

The market price of beef is considerably higher in the United States than in Australia, as the following figures show:

Cattle values at Chicago Saleyards, June, 1951.

Quality	Live Weight	Price realised U.S. dollars	Value in £ Australian
	lb.		
Prime	1000-1500	380-570	138-248
Good	700-1000	255-365	112-161
Poor	700-1500	231-495	102-219

In July, 1951, cattle sold at Brisbane saleyards at from 96/- to 103/- per 100 lb. dressed weight giving a price per head comparison with the above group as follows:—

Quality	Brisbane Estimated Price £ Australian
Prime	34-51
Good	23-32
Poor	20-42

The American beef cattle show a far superior finish and higher quality generally although the dressing percentage is considerably lower.

It must be borne in mind, however, that wage earners receiving £10-£30 weekly in Australia would be paid £31-£88 in the United States.

In considering production of beef in the United States, the price of foodstuffs is

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of interest. Many cattle which arrive at the market have cost the vendors their price as feeders, plus 50 bushels of corn per head as well as hay, molasses, protein meals and licks. Corn is only 14/- a bushel in the United States, compared with over 17/- in Queensland; other fodders are also appreciably higher in price here.

One lot of beef cattle observed by the writer in the middle of 1951 had been wintered from October to April on brome grass pasture plus lucerne silage and 3 lb. corn daily; their average weight increased during this period from 382 lb. to 540 lb. The supplementary feed was then increased to 11 lb., producing a monthly weight gain of 60 lb. It was expected that towards the time of marketing in October, 1951, these animals would be consuming daily up to 16 lb. corn, plus hay and protein supplements.

Feeding 11 lb. corn or alternative grain for a 2 lb. live-weight gain would cost about 3/- per lb. of dressed meat in Australia. Thus grain feeding to bring cattle to forward store condition is not sound under our present economy, and the value of supplementary feeding for fattening is subject to certain qualifications. Conditions which militate against beef production by grain feeding in Queensland are the inadequacy of beef prices, the high prices of feeding stuffs, and lack of competition for young quality beef in open market.

Under the American economy, competitive buying yields high prices; there is a demand and an appropriate price for quality, and feeding stuffs, especially high-protein foods which show economic returns when converted into beef, are readily available. High crop production per acre with limited labour is possible because of mechanization and response to fertilizers.

Present production of grain and high-protein foods in Queensland is too small to provide for extensive supplementary feeding of beef cattle. The greatest incentive to beef production could come from the use of sorghums in the drier agricultural areas of the State, with the assistance of lucerne and high-protein pastures in the irrigation areas. Sorghum grain has given results equal to 90-95 per cent. efficiency of corn, and stubble grazing is also satisfactory. In America it has been found to be economically sound to crush sorghum grain for stock feeding. The sweet or fodder sorghum will play a large part in supplying grazing and roughage in the form of silage. Stimulation of cotton and linseed production in the State might be expected to place more high-protein feeds on the market as these are essential for satisfactory feeding.

Our best source of high-protein concentrate is meat meal which is in short supply and difficulty is experienced in feeding it to livestock. With a slight improvement in beef prices and a system of grading allowing a premium price for quality meat, an economic return might be obtained by supplementary feeding of cattle which reach forward store condition on natural pastures which, for seasonal or other reasons, would not fatten them. A short-term feeding period of 8 to 10 weeks would frequently permit the marketing of cattle which would otherwise be held until the next favourable season.

Buying and selling of cattle

The methods of marketing cattle in the United States can be conveniently grouped into four systems, but initially the basic principle of costing should be referred to, as it differs entirely from the common Australian practice.

The Australian system is based on a per head basis in conjunction with an estimate of quality, yield and weight, and although prices are quoted as so much per 100 lb. dressed weight at markets, the purchase of individuals, pens or store lots on a property is made on a standard of price per head. The American system is based on price per lb. or per 100 lb. and

the livestock are actually weighed. The price per lb. or per 100 lb. is based on the grading as related to quality and yield, but the total weight of the animal is of little significance. The weighing of cattle is done immediately after sale, and in cases where travelling to scales is necessary, an allowance for shrinkage is made. The average American fattener cannot believe the accuracy obtainable by the Australian buyer in estimating the dressed weight of a beast. Buying on an actual weight basis has many advantages, and though it is impracticable for most purchases made in Queensland, it may be found necessary to apply it to grain and crop fattened stock in due course. Weighing of such stock will be necessary in any event to show the relationship between beef gains and cost of fodder.

The weight basis is very sound in contract buying, where a fattener may order a number of feeder cattle (stores) at an agreed price, the animals to be at a given weight and age at time of delivery.

To return to the marketing methods, the four standard forms are advance or contract purchases, auction selling, direct selling market, and central livestock market. These methods and facilities offer ample scope for competitive trading between the six million farmers and ranchers raising livestock and the 4,000 meat packers and 14,000 other commercial slaughterers of livestock in the United States.

Advance or contract sales

Though not a distinct selling system, this method applies specifically to store cattle (stockers or feeders) and yearlings (calves). Frequently a feeder will purchase cattle personally or through an order buyer for delivery some months ahead, stipulating that the number average a certain weight, and contracts for a definite price. In all cases a shrinkage percentage is allowed. Some contract buyers take regular numbers each year from the same breeder and this appears to be a desirable system. Some speculation in prices occurs with buying of "futures".

Auction selling

This method is mainly employed at small country yards by agents working on a commission basis. It is a form widely practised in Australia.

Direct selling market

Under this system, livestock are sold direct from farms to a meat plant or meat packer's buyer or to an order buyer (one who meets the requirements of feeders, stockers or meat plants). Cattle purchased in this manner are usually slaughtered close to the farm where they are finished off. It is understood that direct selling is not encouraged by many dealers, who favour the price-stabilising effects of the large public livestock markets, where all information from other sale centres is posted at hourly intervals during active trading.

Direct selling is common in Australia, especially when dealing in large numbers.

Central Livestock Markets

These markets handle the greatest number of sales of livestock and have been designated by the United States Department of Agriculture as "Public Stockyards". Developed about 100 years ago as Union Stockyards, they serve as a place where those who have a surplus may sell to those who have a need for a particular commodity. They have resulted in the centralisation of buying and selling and have given stockmen freedom from speculators and unscrupulous buyers, while providing facilities for stock agents and all other sections concerned with the industry.

There are between 60 and 70 of these Public Stockyards situated throughout the United States. Following "posting" by the Secretary for Agriculture, stockyards are conducted under the provisions

of the Packers and Stockyards Act. In association with the stockyard company is an organisation of agents and commission men called a "Livestock Exchange" for the purposes of establishing and enforcing trading rules and regulations, eliminating unfair practices and improving services to clients.

The livestock markets are well placed geographically in relation to livestock movements, transport, supply and demand of consumers. The main ones are at Denver (Colo.), Chicago (Ill.), National Stockyards (Ill.), Indianapolis (Ind.), Sioux City (Iowa), South St. Paul (Minn.), Kansas City (Mo.), South St. Joseph (Mo.), Omaha (Nebra.), Cincinnati (Ohio), Oklahoma City (Okla.), and Fort Worth (Texas). Of these, Chicago and Omaha are the largest. Some idea of the huge turnover is indicated by the following summarised figures for Omaha:

Receipts of livestock, Omaha Union Stockyard Co., 1950

Cattle	Pigs	Sheep	Total Livestock
1,745,127	2,733,911	898,601	5,377,639

The cattle came from 26 States and Canada; Nebraska (the local State) supplied one million and Iowa half a million.

Of the cattle sold during the year, a million went to local packing plants, a quarter of a million went to packers in 186 cities in 40 states, and half a million stockers and feeders were shipped (transported) to country centres in 28 states. On the biggest day at Omaha some 35,000 cattle were sold, and in the record year 2¼ million cattle passed through the yards. Such a high turnover calls for good organisation of transport and handling facilities. The significance of road transport is apparent from the Omaha figures for 1950 — receivals by rail 258,075; by truck 1,379,379; shipments by rail 247,273; by truck 426,430.

The great importance of motor truck transport may be indicated by the following figures, which show the percentages of total livestock delivered to the public livestock markets of the United States in 1948—cattle 68.7, calves 72.6, pigs 73.9, sheep and lambs 41.8. Road trucking is cheaper than in Australia, due to the low cost of the vehicles and fuel, and good highways assist speedy movement. Many of the largest feed lots are located near market centres and road transport is obviously the most suitable. Some 80 per cent. of beef cattle is marketed from farms which necessitates a lot of small lots and motor vehicles are most suitable for transport of small numbers to sale centres. Under Queensland conditions where large mobs, long distances and poor roads are involved the motor transport does not compare favourably with railways.

The value of beef cattle and the cheapness of vehicles and running costs in America favour road transport and cattle are seldom walked in America once put into fattening pastures or pens.

Cattle throughout the markets are bought on a live-weight (weighed) basis after agreement on a price per lb. Pens are inspected by buyers, who offer the agent (or owner) a price. The large numbers of buyers and sellers result in keen competition and yet fair trade prices. The rapid turnover does not necessitate pen auctioning, although weekly fluctuations are affected by supply and demand.

The buyers present at the sales include:—

(a) National packers with plants locally or elsewhere who process meat and distribute to other parts and other countries. They can buy all types, weights and grades of livestock.

(b) Local packers with plants adjacent to yards but with some limitations on kinds, weights and grades required for local and interstate trade.

(c) Butchers with requirements for limited distribution.

(d) Packers located at other places who buy through market agencies, or order buyers with a selective demand who are usually prepared to pay commensurate prices for selected livestock.

(e) Dealers or traders who buy and sell for profit but who fulfil the need of assembling, sorting and selecting livestock to meet buyers' requirements.

(f) Feeders and ranchers who buy directly or through order buyers and market agencies from other agencies or dealers in the market.

The facilities of the markets are adequate for the speedy and safe receiving, handling, feeding, watering, selling, buying, marketing, weighing, holding, delivery and shipment of livestock. Included are sanitary facilities (dips, sprays and vaccination and testing areas), all of which, together with offices for agents, are provided by the livestock company. Railway companies provide trains and transport information. Government agencies arrange inspection of livestock and facilities, supervise practices, regulate rates and charges, and investigate complaints and claims for loss and damage. Radio and news agencies supply market news and information. Banks and the market exchanges complete business deals on the spot.

Conclusions

The American beef cattle business is large and well organised. The relationship of grain and fodder costs to beef price allows extensive economical feeding. The market is competitive and price for quality is maintained. Saleyards, processing plants and facilities are located where the cattle are fattened and the majority of these centres are well inland.

In Queensland, grains and fodders can be sold more profitably by means other than conversion to meat products. Only a large extension of agricultural areas or an increase in meat prices will stimulate crop and grain fattening. Any organised system of fattening which will guarantee regular buying of stores from the breeding areas will result in a higher percentage turn-off of cattle. It is desirable that price adjustment be made for quality and that breeding properties sell their stock as stores at an early age.

As transport by road is difficult in Queensland added railway routes will assist the movement of store cattle and with modern facilities on these lines it may become practicable to set up slaughtering and processing plants in the regions where livestock are fattened.

The American marketing methods are not applicable to Australian conditions at present but future developments in this country may well be guided by such a vast progressive industry which has induced a rapid turn-off of high-quality livestock.

(*Received for publication August* 11, 1952).

TECHNICAL NOTES

A HAND-OPERATED ROTARY WEEDER

Agrostologists, plant breeders and other agricultural workers who, in the course of their investigations, must raise large numbers of prostrate herbaceous plants as spaced seedlings, have found that the control of weeds, particularly during the early stages of seedling development, is one of their greatest problems. Weeding with the usual hand hoes is slow and laborious, and often results in the injury or death of an indeterminable proportion of seedlings, and, under wet-ground conditions, winter-growing weeds and grasses are difficult to check unless the operation is repeated frequently.

The winter-weed problem has been particularly acute at the Pasture Research Station, Burnley, during the recent wet years despite efforts to improve soil working conditions by drainage and the use of soil ameliorants. In order to overcome the problem of weeding spaced plants in nursery rows, the writer devised a rotary hand weeder that is operated in a vertical position over the centre of the plant.

This weeder has been well tested, and has been found so effective in destroying weeds, especially *Poa annua*, growing around and under the foliage of clover and medic seedlings, that it has been thought desirable to bring the utility of the device under the notice of other workers who may be confronted with a similar problem to that experienced at Burnley.

The tool (illustrated in Figure 1) consists of a steel tube with turning handles at the top and two claw-shaped double-edged blades attached to the base, pivoted on a spiked central rod. The cutting portions of the blades, which are turned inwards and set at right angles to the axis of rotation, come to within a $\frac{1}{2}$ in. of the spikes projecting from the lower end of the rod. A ferrule at the base of the rod fixes the plane of rotation of the blades at the required level, depending on the depth to which the spikes are pressed into the ground. The blades are sharpened

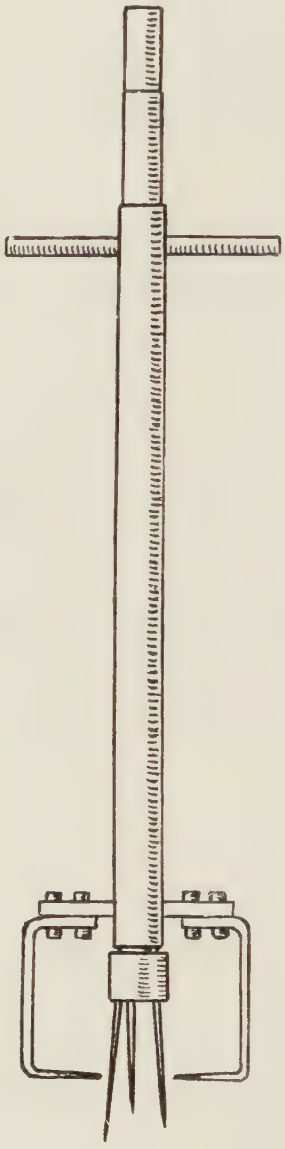

Figure 1.—Showing nature of weeder.

on both sides for cutting into the soil in either direction of rotation.

To operate the weeder, the sleeve is lifted while the rod is set in a vertical position over the centre of the plant, the spikes, which are set in the form of a tripod, being inserted over the crown, thus protecting the stem. The sleeve is then lowered and the blades worked carefully through the foliage and into the soil. A few half-turns in both directions is all that is necessary to effectively destroy all weed growth around and below the foliage.

In constructing the tool, its size may be varied to suit requirements, but the materials used must be sufficiently strong to withstand the forces applied.

The tool used at Burnley cultivates a circular area 9 in. in diameter, and was constructed as follows:—

A 3 ft. 6 in. length of light steel tubing with an outer diameter of $1\frac{3}{4}$ in. was used for the central rod and a 3 ft. length of motor car exhaust steel tubing of 2 in. outer diameter was used for the rotating sleeve. A short length of round wood $1\frac{3}{4}$ in. diameter was tapered and driven tightly into the top of the central rod leaving about 4 in. projecting to serve as a handle. A ferrule was welded on at the base of the inner rod which was then plugged with wood into which were driven three short spikes formed from 4 in. nails with the heads removed. These spikes were set at a slight angle forming, in effect, a small tripod.

Strong iron brackets 3 in. in length were welded to each side of the lower end of the sleeve, and two bolt holes were drilled through each bracket for the attachment of the blades. Short iron rods welded at right angles to the upper end of the sleeve serve as handles for turning.

The cutting blades were formed from 12 in. lengths of 1 x $\frac{1}{8}$ in. steel strap drilled as required for bolting to the sleeve brackets and sharpened on the cutting edges.

It is desirable that the bore of the sleeve be only slightly larger than the outside of the inner tube, and for ease of turning, the bearing surfaces should be kept well greased.

Compared with the conventional hand hoe, this tool has several advantages in the maintenance of spaced plants in nursery rows. The danger of cutting through the main stem of the plant is eliminated providing the operator is careful in placing the spikes over the crown. Weeds are completely destroyed and mulched with the soil. Little or no soil is removed from around the plant by the operation. The work can be done faster and with less effort, and the operator does not need to stoop.

An interesting development from the use of this weeder is that under the weed conditions experienced at Burnley, it gives promise of providing a means whereby spaced nursery plants in rows may be grown without the necessity for inter-row cultivation. Providing the weeds immediately adjacent to the nursery plants can be destroyed, the weeds between the rows can be allowed to grow unchecked, or merely topped with a motor scythe during the winter and early spring, when the ground is unworkable by means of the ordinary cultivating implements.

By the elimination of frequent inter-row cultivation, and the adoption of a technique whereby the trials are conducted "under grass", i.e. making use of a grass cover between the rows, soil erosion should be prevented, soil structure and fertility improved, and the wear and tear on cultivating implements greatly reduced.

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A RADIO FREQUENCY SOIL MOISTURE METER

In studies on *Chondrilla juncea* (Skeleton Weed), it was necessary to grow plants in cardboard tubes. These tubes were 3 ft. long and $2\frac{1}{2}$ in. in diameter. During the studies it became necessary to determine the depth to which water penetrated when the plants were watered. This problem was overcome by the development of an R.F. moisture meter which eliminated the need for direct contact with the soil.

In this meter a small battery-powered oscillator, operating in the 2 to 4 megacycle range, is loosely coupled to a resonant or output coil feeding a pair of suitably mounted and shaped metal "fingers" per medium of a twin twisted flexible line. On placing the "fingers" around the tube, a current is indicated on a microammeter, the amount being influenced by the moisture content of the soil within the tube at the point of testing. Figure I shows the circuit used.

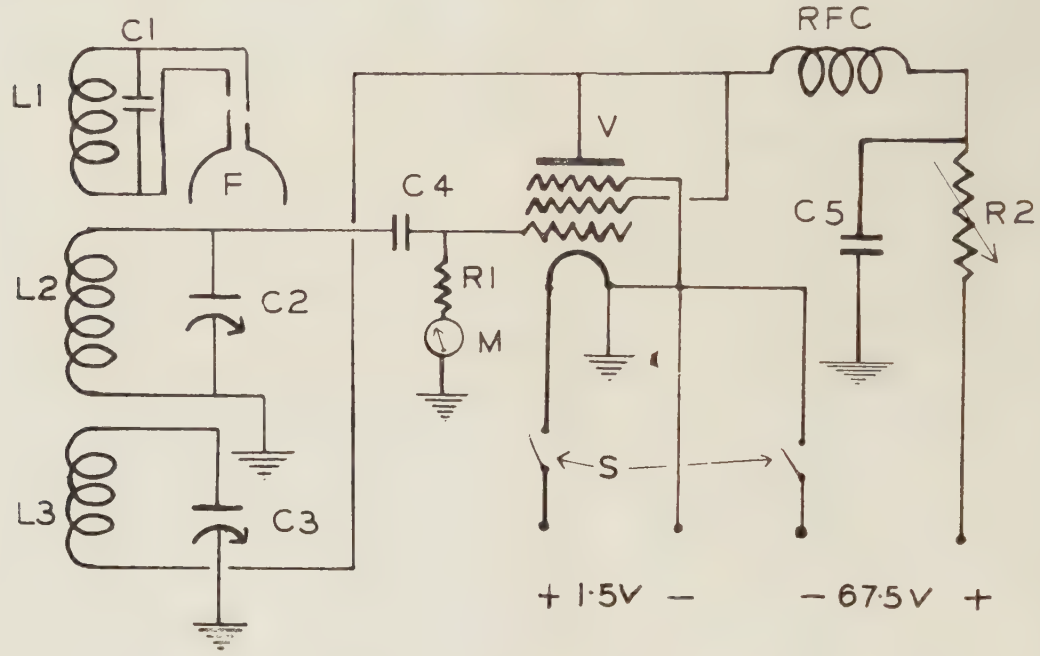

Figure 1.—Showing circuit used.

LEGEND

R1 = 50,000 ohm $\frac{1}{2}$W
R2 = 10,000 ohm W W
C1.C4 = 200$\mu\mu$F
C2 = 11-430$\mu\mu$F
C3 = 60$\mu\mu$F
C5 = .1μF
M = 50μa meter
V = 1S4 valve
S = D.P.S.T. switch
F = "Fingers" and probe assembly

L1 = 6 turns 18 gauge S.W.G. enamelled on 3 inch perspex frame
L2 = 5 turns 18 gauge S.W.G. enamelled on $2\frac{3}{4}$ inch form
L3 = 4 turns 30 gauge S.W.G. enamelled on $2\frac{3}{4}$ inch form

Coil Spacing:
$4\frac{1}{2}$ inches between coils L1 and L2—adjust for optimum coupling
$\frac{1}{2}$ inch between coils L2 and L3

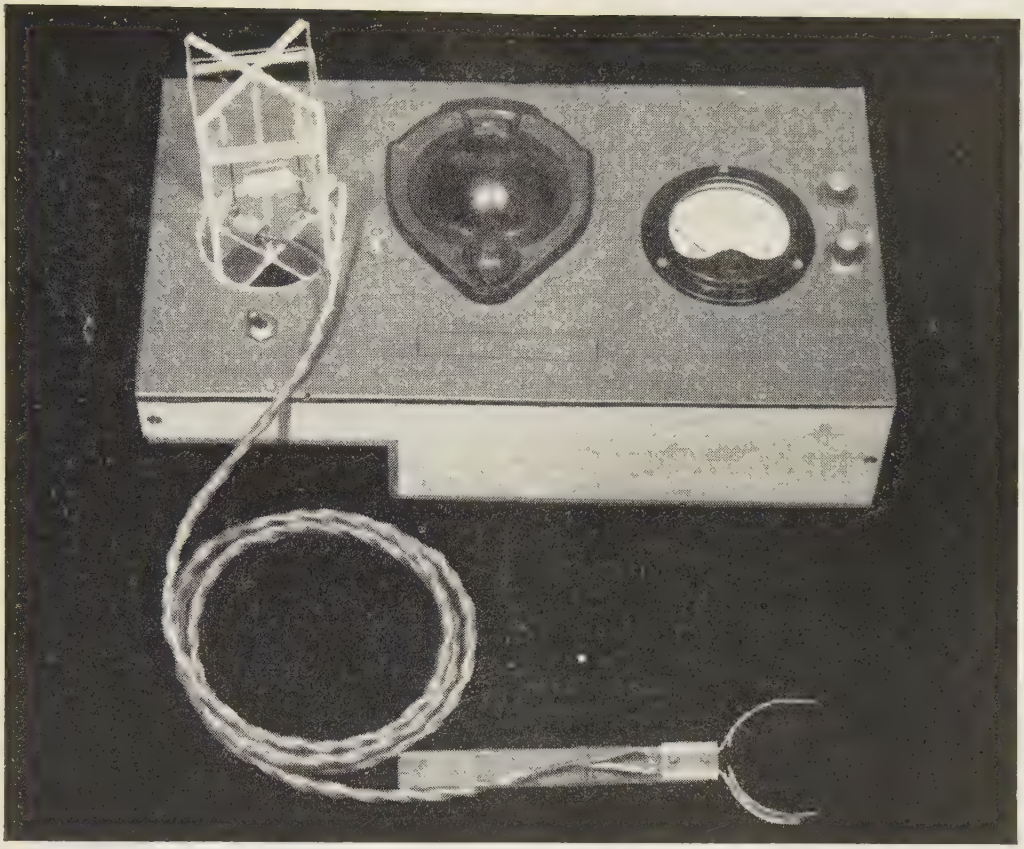

Figure 2.—Showing nature of meter.

The output coil is wound on a frame using two pieces of 5½ x 3 in. perspex as shown in Figure 2; and is detachable for convenience. The "fingers" are two pieces of 18-gauge copper 2½ x ½ in. mounted on a plastic handle as shown. Both size and shape can be varied to suit requirements.

To adjust the instrument for use, the output coil L1 is moved at least 12 in. from the oscillator, and with the tuning condenser C2 near maximum capacity setting, the instrument is checked for smoothness of operation. Oscillation should commence when the feedback control C3 is closed to approximately half. Continued closing will cause an increase in grid current, shown on the microammeter M. It is essential that a gradual increase in meter current be obtained, from zero to 50μA, by adjustment of this control C3, with no sudden changes.

Leaving the control at a 50μA setting, the output coil should then be placed within the grid coil L2. Varying the tuning condenser, whilst maintaining the instrument in an oscillating condition, a position should be found near maximum at which the grid current suddenly drops to approximately zero. By final adjustments to the tuning and feedback controls, a current of 50μA is obtained when both "fingers" are held by the hand, and zero on releasing.

The instrument is now ready for use, and any sample of suitable size, placed between the "fingers" will cause variations in meter current, the amount being influenced by the moisture content.

It is important that the "fingers" and leads are clear of all metal or conductive bodies during adjustments.

In determining the junction of wet and dry soil in a cardboard tube watered from the top, the "fingers" are moved up the tube until the meter current suddenly increases. Examination of soil cores has shown that this method will locate the junction of wet and dry soil to within one quarter of an inch.

C. de PLATER.

Division of Plant Industry,
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Canberra, A.C.T.

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INSTITUTE AFFAIRS

COUNCIL PROCEEDINGS

October Meeting

The 127th Meeting of Council was held at C.S.I.R.O., Canberra, on Monday, 20th October, 1952.

Present

Mr. C. S. Christian (in chair); Mr. C. M. Donald (N.S.W.), Mr. W. M. Willoughby (Qld.), Mr. C. H. Williams (S.A.), Dr. C. Barnard (Tas.), Mr. A. V. Hill (Hon. Gen. Treasurer), Mr. G. A. McIntyre (Hon. Gen. Secretary).

Apologies were received from Mr. F. O. Grogan (W.A.) and Mr. C. Neal Smith (A.C.T.).

Action was taken on the following matters:—

Rural Extension Services

The committee members nominated by the 19th General Meeting to be responsible for the section on training for extension have all accepted office and methods of procedure are now under discussion.

Enrolments for Honours Students

A request made to the Commonwealth Office of Education for consideration of higher allowances to honours students was rejected on the ground that this would create an anomaly between contemporary students in degree courses of different duration.

Conferences on Food

In response to a request from a committee appointed to investigate the possibility and usefulness of bringing in an overseas authority on the world food situation, the general view of branches was that the subject has already had a great deal of publicity and no useful purpose would be served by pursuing the matter further. An alternative suggestion which has been accepted is that Council commend to A.N.Z.A.A.S. that a prominent agricultural scientist be invited to its next meeting and that the A.I.A.S. offer to entertain the visitor in such States as he visits.

Affiliate Membership

A postal vote has been requested by the Queensland delegate following the acceptance of the amendments to create this class of membership at the 19th General Meeting. Statements of cases for and against the amendments will be circulated with the amendments and ballot slip. It is hoped there will be a heavy poll so that confidence can be felt that the result does in fact represent the balance of Institute opinion.

Membership

Admissions

With the recommendation of the Branch submitting the application and the Qualifications Committee the following applications were approved for **corporate membership**:—

EDWARDS, D. W. (New South Wales)
WARING, H. D. (New South Wales)
LATTER, B. D. H. (New South Wales)
VEARS, C. K. (New South Wales)
STORRIER, R. R. (New South Wales)
MULLIN, M. (New South Wales)
LAWLER, T. R. (New South Wales)
WALKER, M. H. (New South Wales)
CERNY, Z. (Tasmania)
DAVIDSON, B. R. (Victoria)
MACDONALD, R. N. (Victoria)
McKINLEY, G. A. (Victoria)
WILMOT, R. (Victoria)
GRASMANIS, V. (Victoria)
GOODING, C. D. (Western Australia)
PEARCE, G. A. (Western Australia)
HAMON, W. P. (Queensland)
WARING, S. A. (Queensland)

Acting on the approval of the branch submitting the nomination the following corporate members were accepted for **emeritus membership**:—

CARNE, W. M. (New South Wales)
SAVAGE, C. G. (New South Wales)

Resignations

SOUTHCOTT, Mrs. E. M. (New South Wales)
NORTH, D. S. (New South Wales)
ARVIER, A. C. (Queensland)
THOMAS, P. H. (Tasmania)

Deaths

FURBY, E. (New South Wales)
McCARTHY, T. (New South Wales)

Transfers

HILLS, K. L. (Australian Capital Territory to Victoria)

Cancellation of Student Membership

EDWARDS, D. W. (New South Wales)
LATTER, B. D. H. (New South Wales)
STORRIER, R. R. (New South Wales)
LAWLER, T. R. (New South Wales)
WALKER, M. H. (New South Wales)
GOODING, C. O. (Western Australia)
PEARCE, G. A. (Western Australia)

BRANCH NOTES

Australian Capital Territory

Dr. D. E. Tribe, of the Rowett Institute, Aberdeen, Scotland, addressed a General Meeting of the Branch on Friday, 12th September, on the subject, "The Importance of Animal Behaviour Studies in Animal Husbandry." In the course of his address which evoked considerable interest, Dr. Tribe revealed some very interesting though conflicting information on the ability of animals to select diets applicable to their particular needs. The results appear to have disproved some of the commonly accepted views in regard to the instinctive ability of the animal to look after its own welfare.

Mr. T. G. Campbell of the Entomology Division, C.S.I.R.O., was the speaker at the General Meeting held on 14th October. Mr. Campbell, who spent a period of four weeks at Cocos Islands during May and June of this year, spoke on the subject, "Entomological Survey of the Cocos-Keeling Islands." In the course of his survey, Mr. Campbell collected 154 species of insects, few, if any, of which are indigenous to the area. Mr. Campbell pointed out the hazards of the accidental introduction to Cocos Islands of potentially dangerous insects from South Africa and Mauritius and advocated that very thorough methods of inspection and disinsectization of aircraft should be carried out on each stage of the journey from South Africa to Australia and vice versa. Because of the equable climate of the Cocos Islands and the presence there of numbers of economic plants, this area, in the absence of strict quarantine measures, could become a very real danger to Australia, Mauritius and South Africa, in regard to the introduction of serious insect pests.

The November meeting was addressed by members of the Land Research and Regional Survey Section while Dr. J. G. Davies addressed the Branch in December on his visit in an official advisory capacity to Baluchistan, one of the States of Pakistan.

New South Wales

At a general meeting on 30th July, 1952, Mr. J. S. Bunt gave an entertaining address on "The Australian National Antarctic Research Expedition to Macquarie Island." Mr. Blunt had recently returned after spending twelve months as biologist to the expedition.

The speaker outlined the history of the expedition and showed how interest had increased in the Australian Antarctic. He then described the position, climate, flora and fauna of the island.

Macquarie Island is about 1,000 miles south-east of Hobart and is the only piece of land in a vast stretch of ocean. It is about 20 miles long, $1\frac{1}{2}$ to 2 miles in width, and rises steeply from the sea. Most of the area is a glacial plateau 800 - 1,000 ft. above sea level. The rock is basaltic and the topography very rugged.

The temperature is fairly uniform throughout the year, averaging 40°F. with a maximum of 51°F. and a minimum of minus 17°F. Strong winds are almost incessant and there is much fog and low cloud. There are very few hours of clear sunshine.

The island is not covered with ice and snow and 38 species of vascular plants have been recorded. Most of these are thought to have been introduced by migratory birds. Giant kelp is present near the rocks surrounding the island and high up there are many mosses. The island is a breeding ground for millions of birds and seals and numbers of rabbits, cats, rats and mice have been introduced.

The activities covered by the expedition include meteorology, geophysics, radiophysics, cosmic ray physics, auroral observations and biology. Special importance is attached to the meteorological and ionospheric work.

Mr. Bunt's address was followed by a most interesting film entitled "Penguin Island" which demonstrated many of the features of his talk, in particular the diversity and abundance of wild life.

The guest speaker at a meeting held at the Faculty of Agriculture on 29th September, 1952, was Professor T. G. B. Osborn, Professor of Botany at Oxford University, who previously occupied chairs in Adelaide and Sydney.

Professor Osborn discussed "Some Recent Trends in British Botany." He showed how botany, which was previously concerned mainly with morphology and phylogeny, has become more and more a study of the plant and its relation to the environment in the widest sense. There have been great advances in genetic analyses and cytology and, in the more practical field, there has been much work on self-sterility, incompatibility and the need for pollinators in orchards.

An increased amount of time is being devoted to plant physiology, growth-regulating substances and minor element effects. In the field of plant ecology notable advances have been made in the understanding of proper grazing management and in the choice of pasture mixtures.

Under the heading of plant pathology, studies on host-parasite relationship, resistance and the effect of environment have been numerous. The virus-free potato scheme conducted by the National Institute of Agricultural Botany at Cambridge supplies virus-free seed to the trade and, in this way, the incidence of virus diseases has been greatly reduced.

Professor Osborn discussed the administration of research institutions in Great Britain. Some of these are attached to Universities but many have been established under endowments. Many of the latter class, such as the John Innes Institute and Rothamsted receive government help but are not directly under government control.

Queensland

The August meeting was devoted to notes and exhibits. The main contributor was Mr. A. P. Dodd, Director of the Biological Section of the Department of Public Lands, who spoke on the stem gall fly which was recently introduced from Hawaii for the purpose of controlling Crofton weed *(Eupatorium adenophorum)*, a serious weed of pastures in south-eastern Queensland and northern New South Wales. The fly was introduced to Hawaii from Mexico in 1945 and has succeeded in reducing Crofton weed infestation in the Hawaiian islands by more than half. After personal visits to Hawaii, Mr. Dodd arranged for the introduction of the fly to Queensland, and it has since been liberated at seven locations. The eggs of the fly are deposited on the growing points of the plant when the larvae hatch they enter the growing point and a gall develops. The effect of the galls is to prevent seeding.

Mr. R. B. Morwood exhibited specimens of Victand oats affected by helminthosporium blight, a disease new to Queensland. The appearance of this disease is causing some concern, as crosses incorporating Victoria are the most useful fodder

oats in coastal Queensland. If the disease seriously reduces the value of the Victoria crosses in use, it may be possible to secure a variety combining leaf-rust resistance and helminthosporium-blight resistance by using material containing Bond blood which is held by the Department of Agriculture and Stock.

Mr. F. Chippendale exhibited an enlarged aerial photograph of the Herbert River lands, near Cardwell, and commented on the topography, soil types and vegetation with the aid of coloured transparencies.

The Branch President (Mr. P. J. Skerman) showed photographs of machinery developed in New South Wales for sowing clovers seeds in paspalum sod. He also displayed a map showing the distribution of alluvial soils along streams in south-eastern Queensland in relation to areas of tertiary basalt and expressed the view that the prospect of obtaining underground water for irrigation purposes in proximity to tertiary basalt flows appears to be good.

In association with Mr. G. H. Allen, the President discussed the 1951-52 drought in the north-west of Queensland and adjacent parts of the Northern Territory. A map was exhibited to show the movements of stock from the drought-affected areas to agistment. Over half a million sheep have been removed from the worst affected sheep area this year, and four-fifths of these have been moved by railway. The availability of agistment country and the supply of fodder for supplementary feeding were discussed.

The September meeting was a joint meeting with the Queensland Branch of the Australian Society of Dairy Technology for the purpose of hearing an illustrated address on agriculture and dairying in Pakistan given by Mr. E. B. Rice, who early this year spent a period in Pakistan under the Technical Assistance Scheme of the Colombo Plan.

South Australia

A meeting was held on 19th September at the Waite Institute, when Dr. R. J. Best gave an address on "Some Impressions of Agriculture Abroad." Dr. Best described his experiences and impressions during his recent trip to North America and Europe, the emphasis being on plant virus studies and soil chemistry. The address was illustrated with many Kodachrome slides. Of particular interest was a series of slides showing land building and "planned erosion" in Holland.

At the meeting, the financial results of the Second Annual Stud Stock Supplement, prepared by South Australian Branch members for the "Chronicle" were disclosed. A cheque for £90 was received at the meeting and paid into Branch funds. The Supplement this year was larger and contained articles of a higher standard than the 1951 issue and was well received by readers.

The President (Dr. McCulloch) reported the proceedings of the nineteenth Council Meeting to the Branch and conveyed to members the decision of Council to locate Federal Headquarters in South Australia, as from 1st January, 1953. The additional responsibilities which would be thrown on the Branch were outlined and members were asked to give serious thought to these responsibilities, especially the provision of Federal office bearers and proxy delegates.

Tasmania

Continuing its programme of discussing means of increasing food production, the branch held another meeting in its series on September 22nd. Papers were presented by Dr. Wilson and Mr. Raphael on potatoes and vegetables respectively, after which general discussion was held.

An open general meeting of the branch was held on October 14th and was addressed by the Chief of the Division of Plant Industry, C.S.I.R.O., Dr. O. H. Frankel.

Dr. Frankel compared agricultural research in New Zealand and Australia and its influence on recent agricultural production trends.

New Zealand has a temperate climate and well distributed rainfall. Australia on the other hand has large zones of hot climates with seasonal or irregular rainfall.

New Zealand is small and compact with few natural resources—rain and sunshine are her principal assets. Australia is vast and has great mineral resources.

Hence New Zealand's principal national effort has been and is the development of farming, but Australia's is widely dispersed.

Agricultural research and extension in New Zealand are much more intensive in terms of population, size and nature and magnitude of the problems than is the case in Australia. New Zealand's expenditure on agricultural research in 1951-52 was probably not less than three-quarter of a million. Australia's probably not more than two millions. New Zealand with onlv 100,000 square miles—one-third of New South Wales—has in its agricultural extension service, almost the same number of officers as has the whole of Australia. Agricultural research and extension in New Zealand have paid enormous dividends and continue to do so. Even in Tasmania, so similar to New Zealand in many respects, not nearly all the known improvements in agricultural technique are being utilised. Production could be very greatly increased if all that we know now were applied.

In New Zealand there is a flight of university youth from biology and agriculture to chemistry and physics, but nothing like the disastrous trend in Australian Universities where the great biology departments are almost denuded of students. Capital of brains and initiative is limited. It is now disastrously being withdrawn from the basic industry of the country.

The task of tapping the almost undreamed of resources of the Australian soil lies before generations to come—a hungry world is asking for food rather than uranium. Can Australia afford to divert its brains, its initiative and its capital resources from what is and must remain, its main contribution to the world—its soil?

Victoria

The Branch arranged the preparation of a Royal Show Supplement which was published in the "Age" newspaper. The contributions, covering many facets of agriculture, were all by Institute members. Due acknowledgment was given of the role of the Institute in providing authoritative articles, and proceeds were donated to Branch funds.

The Annual Dinner of the Branch was held at the William Angliss Food Trades School on 23rd September. The reputation which these annual functions have deservedly gained was vouched for by the record number of applications to attend. Only members and official guests could be accommodated. This year's dinner came up to expectations in every respect.

Western Australia

An ordinary general meeting was held on the 9th June, when members were addressed by Mr. T. C. Miller, on "Agriculture in Pakistan." Mr. Miller, who is on loan from the State Department of Agriculture to the Government of Pakistan, outlined the social and economic conditions in the North West Province and described the various crops grown in that region.

The main business at the ordinary general meeting held on the 11th July was a talk by Professor A. D. Ross on "The Pan-Indian Ocean Science Association."

Professor Ross, former Head of the Physics Department, University of Western Australia, referred to the success of Pacific Science Congresses which had been inaugurated in 1920 and described how National Committees have been set up in member countries. After the address he screened a series of colour photographs which gave members a good insight into conditions both in town and country in India.

At the ordinary general meeting held on the 22nd August the guest speaker for the evening, Mr. N. Stenhouse, addressed members on the subject of "Statistics." Mr. Stenhouse, a Biometrician with the C.S.I.R.O., and stationed at the Institute of Agriculture, University of Western Australia, outlined the application of statistics to agricultural surveys and experiments.

On the 8th September Dr. D. E. Tribe delivered an address on "The Place of Animal Behaviour in Animal Husbandry." Dr. Tribe is visiting Australia on a Nuffield Scholarship and has made a special study of animal behaviour. Some interesting experiments to decide whether the animal has an "appetite instinct" to select a properly balanced diet were described.

It appears that the preferences of animals are no guide and that the selection of deficient dietary components only occurs when physiological benefits are rapid enough to be appreciated by the animal.

Mr. Henry Schapper, Research Fellow in Farm Management, at the Institute of Agriculture, University of Western Australia, gave an address on the 26th September, entitled "Agricultural Extension and Farm Management."

Mr. Schapper stated that it is generally recognised that more attention should be paid to the efficiency and purpose of extension services. He stressed the opinion that now that the pioneering stage had been passed in agricultural development more emphasis should be placed on extension in the fields of farm management nad rural economics.

The West Australian Branch of the A.I.A.S. proposes to hold a post-graduate refresher course with the theme of "Advances in Agriculture" at the University of Western Australia during the period February 23rd to March 6th, 1953, inclusive. The object of the conference is for most members to contribute a short paper of from 15 to 20 minutes duration and for each paper to be followed by a discussion period of 10 to 15 minutes.

It is hoped that the meeting will be attended by all the local administrative, research and extension workers whose interests lie in the field of agricultural science.

From this free interchange of technical ideas and information must result an improved advisory service as well as a better definition of desirable fields for future agricultural research.

The proposal has received generous support from the West Australian Department of Agriculture both financially and in the matter of leave for attendance at meetings. A charge of £2/2/- each will be made to help cover the costs of the conference. Copies of the proceedings will be printed.

PERSONAL NOTES

Australian Capital Territory

Mr. C. G. Greenham, Principal Research Officer, Division of Plant Industry, C.S.I.R.O., Canberra, recently returned to Australia after a period of nine months overseas. His main interest was research in auxins and herbicides, but other interests were tracer and biophysical methods.

Three months were spent at the Oxford University, Department of Agriculture, and the remainder of the period at other universities and research institutions in England, Norway, Sweden, Denmark, Holland and the United States.

Miss N. T. Burbidge, Systematic Botanist of the Division of Plant Industry, C.S.I.R.O., Canberra, is going to England for two years as Australian Liaison Officer at the Royal Botanic Gardens, Kew. While at Kew, Miss Burbidge will deal with taxonomic enquiries on behalf of Australian systematic botanists and will also pursue her special research interests.

Mr. K. Loftus Hills of the C.S.I.R.O. Division of Plant Industry is taking up an appointment at the end of October with the Organisation's Agricultural Research Liaison Section in Melbourne. He joined the Division in 1932 and has been en-

gaged since then on research into various aspects of agricultural science, including cereal genetics, pasture plant improvement and more recently the physiology and genetics of drug plants including the Australian species of *Duboisia*.

During 1946 - 1948 Mr. Loftus Hills was responsible for the biological, agricultural and medical work at A.S.L.R.O., Washington, D.C.

Mr. W. F. Owen, Economic Research Officer of the N.S.W. Department of Agriculture, recently returned from America and the United Kingdom and is now completing his thesis for the degree of Doctor of Philosophy at the University of Wisconsin. During his stay in Wisconsin, Mr. Owen took part in the conference on World Land Tenure Reform at which many different countries were represented.

Mr. D. A. Lewis recently arrived in Davis, California, to commence study for the degree of Ph.D. at the Department of Vegetable Crops, University of California. Mr. Lewis was formerly on the field staff of the Batlow Packing House Co-operative, Batlow, N.S.W.

Mr. J. Lamrock has departed for Trinidad to further his studies at the School of Tropical Agriculture. He has been a District Agronomist in various parts of New Guinea since 1949 and hopes to return there after completing his study overseas.

Mr. J. Meers, Cereal Chemist with the Division of Science Services, N.S.W. Department of Agriculture, proposes to leave for England shortly to study cereals and cereal chemistry. Some of his time will be spent with Dr. Kent Jones who recently visited Australia. After leaving England Mr. Mears hopes to visit Canada to gain further experience.

Queensland

Mr. D. R. L. Steindl, of the Queensland Bureau of Sugar Experiment Stations, is to go to California early next year to study methods of virus detection in plants.

Mr. L. E. Nichols, of the Queensland Department of Agriculture and Stock, has been awarded the Silver Medal of the Australian Society of Dairy Technology for a paper dealing with the manufacture of a non-fat-leaking cheese.

South Australia

Professor H. C. Trumble has recently returned from a round-the-globe trip, lasting two months. He visited the Imperial College of Tropical Agriculture, Trinidad, and, afterwards, conferred with the governing body of the College in London. On his way home, he spent a few days at the Headquarters of F.A.O. in Rome, and four weeks at Davis, California.

Mr. A. T. Pugsley acted as Head of the Agronomy Department, Waite Institute, during Professor Trumble's absence.

Professor J. A. Prescott, Director of the Waite Institute, returned to Adelaide in mid-November, having spent six months on study leave in England.

Mr. Keith Woodroffe, for many years a senior member of the Agronomy Department, Waite Institute, has resigned and is to take up a property in the Coleraine destrict of Victoria.

Mr. A. J. K. Walker, Senior Agronomist in the Department of Agriculture and Branch Treasurer, returned from North America early in November. He had attended the Sixth Intenational Grasslands Congress at State College, Pennsylvania, and visited agronomic research centres throughout the United States and Canada.

Dr. T. O. Browning, Entomologist at the Waite Institute, has commenced work under Professor Wigglesworth in the Zoology School at Cambridge. He is studying problems of insect physiology and ecology on a Nuffield scholarship.

Mr. G. R. Edwards, Horticultural Research Officer in the Department of Agriculture, has been awarded a Research Assistantship at the University of California. He has settled in at Davis, in the Department of Vegetable Crops and expects to be away about eighteen months.

Mr. J. W. Ryan, Journalist and State sub-editor, spent six weeks in the Northern Territory during October and November, collecting material and experiences of the beef cattle industry of the North for his paper.

Victoria

Mr. T. C. Bell has returned to Head Office of C.S.I.R.O., after spending five years at the Australian Scientific Liaison Office in Washington.

Mr. A. F. Gurnett-Smith, of the Agricultural Research Liaison Section, has left for a term at the Washington office.

Mr. N. M. Tulloh has been seconded to the position of Primary Industries Liaison Officer in London for a period of 18 months. During his absence *Mr. A. B. Cashmore* is acting as Assistant Divisional Secretary of the Division of Animal Health and Production.

Miss M. F. Simpson, who has been abroad working with London United Dairies, has returned and joined the staff of the Milk Laboratory in the Veterinary Research Institute.

Mr. G. Alexander returned in October to the Animal Health Research Laboratory after two years pursuing advanced studies and research in animal physiology at Yale University.

Mr. W. A. Beattie has completed a survey of the beef cattle industry of the Commonwealth, reports on which are now being published. He has resigned from C.S.I.R.O., to take a position as Pastoral Manager with the Australian Estates Co.

Mr. M. B. Beck has joined the Horticultural Division of the Department of Agriculture, upon resigning from Kraft Walker Cheese Co. He earlier held a position with the A.M.P. in South Australia.

Western Australia

Dr. R. Smith, Senior Research Officer in the Division of Soils, C.S.I.R.O., and stationed at the Institute of Agriculture, University of Western Australia, left in August to take up a 12 months appointment with F.A.O. Dr. Smith is stationed in Iran where his services are to advise the Government and to train local technicians in soil classification and techniques of mapping soils for detailed and reconnaissance surveys. He will also make irrigation compatibility ratings and recommendations for cropping and cultural practices, and will assist in instituting proper

land use in new areas. He has resigned from the position of President of the W.A. Branch of the A.I.A.S.

Mr. A. J. Millington, formerly Vice-President of the W.A. Branch, has now become President for the remainder of the year.

Mr. H. G. Cariss has been elected Vice-President for this year.

Mr. D. K. Giles has resigned from the position of Sub-Editor of the Journal on account of illness and *Mr. L. T. Jones* has been appointed in his place.

OBITUARY

Edward Thomas Morgan

It is with deep regret that we record the death on 2nd May, 1952, of Mr. E. T. Morgan, at the age of 57 years. Mr. Morgan joined the W.A. Department of Agriculture in 1928 and held the position of Officer in Charge of the Vegetable Branch for the last twenty years.

Born in Herefordshire, England, he came to W.A. in his youth and was among the pioneer potato growers in the Benger Swamp.

During his period of administration the efficiency of potato growing in W.A. was increased appreciably as a result of his sound advisory service. He was an enthusiastic supporter of the Certified Seed Scheme and introduced into it the use of tuber-unit plots in the production of seed potatoes.

His keen powers of observation and his widé practical experience enabled him to be one of the first to recognise copper deficiency in vegetable crops in the Albany district.

In his spare time he grew and bred gladioli and his show blooms gained him an international reputation.

LETTER TO THE EDITOR

SULPHUR DEFICIENCY IN AUSTRALIAN SOILS

Sir,

In this Journal for September, 1952, A. J. Anderson stated: "The occurrence of sulphur deficiency in Australian soils was first reported in 1949" (by Anderson and Spencer).

An examination of soil problems of the Lockyer Valley in south-eastern Queensland, commenced by the Queensland Department of Agriculture and Stock in 1943, soon revealed that lucerne growing on soils containing over 1,000 p.p.m. available P_2O_5 (Truog) showed marked response to superphosphate. The matter was investigated on the premise that the response was due to the gypsum in the superphosphate, and (as mentioned in this Journal for December, 1946) gypsum was subsequently found to be as effective as superphosphate. Attempts were then made to ascertain whether the effects of gypsum were due to the nutrient sulphur, to the countering of the adverse effects on soil texture of sodium carbonate in the irrigation waters, or to to the release of potash by the breaking down of relatively insoluble minerals.

D. O. Atherton, reporting on the work of the Agriculture Branch in the Annual Report of the Department of Agriculture and Stock for the year 1947-48 (published in 1948), stated: "Further evidence of lucerne responding to applications of superphosphate on soils containing abundant quantities of available phosphates has been collected. It is considered that the response is due to sulphur supplied in the superphosphate as calcium sulphate, and this view is supported by observations in the Lockyer Valley following applications of gypsum (calcium sulphate)."

The investigations were planned and directed from their initiation by W. J. Cartmill (now Chief Soil Conservationist in the Queensland Department of Agriculture and Stock).

Yours, etc.,

C. W. WINDERS.

Dept. of Agriculture and Stock,
Brisbane.

20/x/1952.

NEWS ITEMS

Journal receives grant from Rural Credits Development Fund

In response to a request from Council to the Commonwealth Bank for financial assistance to help defray the costs of publishing this Journal the Bank has made a generous grant for 1952-53 of £200 from the Rural Credits Development Fund. The Institute has expressed its sincere appreciation of this recognition of its work.

U.N.E.S.C.O. Arid Zone Committee

Dr. B. T. Dickson recently returned from London where he attended the symposium on "The Biology and Productivity of Hot and Cold Deserts" and the meeting of the U.N.E.S.C.O. Advisory Committee on Arid Zone Research.

The symposium was organised by the Institute of Biology at the Royal Institution. It was held September 25th-27th in six sessions:—Climate and Physical Environment, Plant Ecology, Entomology and Ecology, Economic Aspects, Mammalian Physiology and Ecology (two sessions). Dr. Dickson was invited to preside at the session of Plant Ecology.

The Advisory Committee on Arid Zone Research, which met at the Royal Society's rooms, is made up of nine members:—Dr. Hassan Awad (Egypt), Professor Peres (France), Professor Picard (Israel), Mr. Dhir (India), Mr. Boke (U.S.A.), Dr. Thornton (U.K.), Professor Llamas (Mexico), Mr. Zender (Peru) and Dr. Dickson (Australia).

An address of welcome was given by Sir David Brunt, Secretary of the Royal Society, representing the U.K. Ministry of Education and the Royal Society. Dr. H. G. Thornton, F.R.S., was elected Chairman for the fourth session and Mr. Boke, Professor Peres and Dr. Dickson constituted the drafting sub-committee.

Among the twenty-six recommendations which resulted from the committee's deliberations may be noted the following:—In 1953 and 1954 fellowships be given in any field of interest to the arid zone programme; the plant ecology symposium be held in a Latin American country if possible; the symposium be completed in four days and to cover climatic, ecoclimatic and hydrological effect on vegetation, soils and vegetation, and the structural and physiological features of vegetation—all of course as related to arid and semi-arid areas; the preparation of reports reviewing research in the fields of wind energy, solar energy and special problems of hydro-electric power in arid regions.

It was decided to recommend the publication of a directory of institutions engaged in research affecting arid and semi-arid areas especially listing those primarily devoted to such work.

U.N. and F.A.O. Survey in Baluchistan

Dr. J. Griffiths Davies recently spent six weeks in Baluchistan during July and early August this year. He joined a combined team of U.N. and F.A.O. which was formed at the request of the Government of Pakistan The team consisted of:

Mr. M. A. Nicholson, U.N. Leader, U.K.,
Mr. F. O Youngs, F.A.O., Soils and Agriculture, United States,
Dr. J. Griffiths Davies, F.A.O., Range and Livestock, Australia,
Mr. J. S. James, F.A.O., Water and Irrigation, United States,
Mr. W. Henckmann, U.N., Mineral Resources, Germany,
Mr. J. Cruise, U.N., Hydroelectricity,
Mr. S. Madhi Shah, Roads Engineering,
Dr. A. G. Riaz, Soil Conservation Adviser, Pakistan, and
Mr. J. M. Master, Geological Adviser, Pakistan.

The team's task was to examine the developmental possibilities in the economy of the Baluchistan States Union which is one of the member States of the Federation of Pakistan. The total area involved is 81,000 square miles with a population of some half a million people, though the precise number of people is not accurately assessed because a substantial proportion are members of nomadic tribes.

The States Union is an arid, elevated plateau, the northern valley floors are 6,500 feet above sea level, the mountain ranges averaging some 9,000 feet or more with the highest peaks at over 10,000. The southern plateau valleys are generally at 4,500 feet above sea level and the mountains about 7,000 feet. The mean annual rainfall is seven inches, in the north a typical Mediterranean distribution and in the south a monsoonal one—with over 70 per cent. falling in the two months, July and August. There are small but significant areas of irrigation from natural springs and artificially built kharezes; these may deliver from one to seven cusecs. The main crops grown are wheat, sorghum, potatoes, mung and vegetables with a small amount of lucerne.

The pastoral industry is based on sheep and goats—for wool and hair, meat and milk. Camels and donkeys provide the power and transport. Upwards of 40 per cent. of the people are nomadic.

The people are of the Brahui race, speaking their own language, are devout Moslems and a proud, independent and intelligent people. Their agricultural and pastoral methods are extremely primitive and their way of life simple in the extreme.

Land Research and Regional Survey—Northern Australia

The survey unit of the C.S.I.R.O. Land Research and Regional Survey Section returned to its headquarters in Canberra during September, after nearly four months field work in the Ord-Victoria Rivers region in northern Australia. This was the second field season in that area and completed the field work for the Ord-Victoria region.

The next region to be surveyed is the Gulf country of Queensland and the unit is planning to commence work there in May, 1953.

Sixth International Grassland Congress

Dr. J. Griffiths Davies led the Australian delegation to the VI. International Grassland Congress held at State College Pennsylvania from August 17th to 23rd inclusive. Members of the official Australian delegation were Mr. Selwyn Everist from Queensland and Mr. A. J. K. Walker from South Australia. Mr. M. C. Franklin of the McMaster Laboratory, and Mr. J. D. Brookes, Melbourne, also attended as members of the Congress.

Dr. P. V. Condon was appointed President and Dr. Davies was honoured in being elected as a Vice-President—a tribute to Australian grassland research as well as to his own part in it.

Fifty-three countries were represented by over 400 delegates and members—the total membership of the Congress exceeding 1,200. Three plenary sessions were held and twelve sectional programmes proceeded simultaneously.

A. Genetics and Breeding.
B. Improvement and management of pastures, meadows and turf.
C. Improvement and management of range lands.
D. Ecology and Physiology.
E. Soil management and fertilisation.
F. Seed production and distribution.
G. Soil and water conservation.
H. Harvesting and preservation of forage.
I. Use of forage in livestock feeding.
J. Machinery.
K. Experimental procedure in grassland research.
L. Improvement and management of tropical grassland.

The Congress was excellently organised and the papers read greatly stimulated thought and discussion. The broad international representation provided an unique opportunity of meeting grassland workers from every part of the world, except the "Iron Curtain" countries. The past Congress tours were designed to illustrate the enormous economic importance of grassland in the United States, and as Secretary for Agriculture for the U.S.A., Mr. Charles F. Brannan stated in his plenary address to the Congress it was clear that the major economic developments in United States agriculture are coming from research and extension on their grasslands.

The VII. Grassland Congress will be held in New Zealand late in 1956.

New Research Area in South Eastern South Australia

With the opening of a new experimental area of 500 acres at Willalooka, in the Coonalpyn Downs, near Keith, a reorganised pattern of investigational work in south eastern South Australia has been launched by the Department of Agriculture. The Kybybolite Experimental Station has been renamed Kybybolite Research Centre and with Research Centres at Struan (in rendzina country) and Willalooka as out-stations, a good coverage of type areas of the south east for investigational work has been established.

The Willalooka Research Centre, which is representative of much of the land being developed by the A.M.P. Society for settlement, will be used initially for the investigation of beef cattle breeding in the area. In co-operation with the Division of Biochemistry and General Nutrition of C.S.I.R.O., the problem of "phalaris staggers" in cattle and sheep is also to be studied.

It is planned to follow up this work with a number of agrostological investigations pertinent to the area.

David Adam Memorial

A fund has been opened to provide a Memorial to the late D. B. Adam, formerly Reader in Plant Pathology at the Waite Institute, University of Adelaide. A committee, comprising Dr. N. T. Filentje and Messrs. A. G. Strickland and T. T. Colquhoun, is administering the Fund. It is expected to provide an annual prize in the Faculty of Agricultural Science for the best student in Plant Pathology. This will be the first prize to be awarded in the Adelaide Faculty.

Any contributions, no matter how late, are very welcome and should be sent to Dr. Filentje at the Waite Institute.

Cereal Breeders and Geneticists Newsletter

The first issue of this publication came out early in November, with contributions from all over Australia. The Newsletter is edited by Mr. G. M. E. Mayo and it is expected to provide a very useful exchange medium and link between geneticists, breeders and other interested workers in the cereal field. The publication was recommended by the Conference of Cereal Breeders and Genticists held at Wagga in 1951.

Cool Room at the Waite Institute

This experimental unit, designed to enable plants to be grown throughout the year at temperatures below summer macima, will shortly go into operation. It has been financed by the Rural Division of the Commonwealth Bank.

New Pests in Tasmania

Within the past twelve months, three new entomological pests have been detected in Tasmania.

The first was the Argentine ant which was found in an isolated area in southern Tasmania. Steps have been taken to try to eradicate this species before it becomes firmly established.

More recently the Sirex wood-boring wasp has been detected in a pine plantation some distance from Hobart, and the Tarsonemid mite of Strawberries has been identified from various areas of the State.

Neither of the latter two species has been recorded from the Australian mainland. Both are serious pests in overseas countries.

Survey of the Sheep Industry in the Western District of Victoria

Results of a survey of the sheep industry in the Western District of Victoria, carried out during 1947 and 1948 as part of the research programme of the School of Agriculture, University of Melbourne, have recently been published. The authors, P. S. Lang, N. M. Tulloh and B. V. Fennessy, have described the Western District and its agricultural utilisation, and the stages of development which have been reached in the modification of the natural vegetation.

Their critical analysis of the practices of sheep management represents more than a mere record of survey data and serves to place in perspective the main problems of the farmer and to indicate the limitations in existing knowledge and its application.

A notable feature is the chapter on flock replacement and breeding policies, in which characteristics and implications of flock dynamics are carefully analysed.

The bulletin presents a balanced picture of the present status of the industry and should be valuable in revealing the most fruitful lines for research, extension and practice by which efficiency may be enhanced. It may also serve as a model for the execution and reporting of surveys. A limited number of copies is being distributed by the School of Agriculture.

Conference in soil science, 1953

A conference in soil science is to be held at the Waite Institute, Adelaide, for six days, from May 27th to June 3rd 1953 inclusive. It is being jointly organised by the C.S.I.R.O., Division of Soils, and the Waite Agricultural Research Institute, University of Adelaide.

The conference is intended as a medium for discussion of current research in soil science, with special emphasis on the Australian environment. It is for the exchange of information, and debate on various aspects of soil research, and is not a continuation of the soil schools held in Adelaide in 1939 and 1945.

Correspondence and enquiries regarding the conference should be addressed to the Secretary, Soil Science Conference, Waite Institute, Private Bag, Adelaide, S.A.

BOOK REVIEWS

THE INJURIOUS INSECTS OF THE BRITISH COMMONWEALTH (EXCEPT THE BRITISH ISLES, INDIA AND PAKISTAN)

By J. W. EVANS

(*Commonwealth Institute of Entomology, London*, 1952, 242 *pp.*, 30/-).

The author of this volume is well known in Australia as he was for some time associated with C.S.I.R.O., and later occupied the post of Chief Biologist in the Tasmanian Department of Agriculture. At present he is attached to the Commonwealth Institute of Entomology in London. Regarding his entomological background it might be mentioned that he is a son of Brigadier General Evans of the British Museum, a world authority on Skipper butterflies, and a son-in-law of the late R. J. Tillyard who was Chief of the Division of Economic Entomology of C.S.I.R.O. Besides being a good economic entomologist, the author is a taxonomist of no mean calibre.

This book is divided into five parts, the first giving a brief outline of the principal insect pests of plants, and insects of medical and veterinary importance throughout the territories of the Commonwealth. The main crops grown in the areas are noted and reference also is given to some of the economic publications pertaining to those areas.

Part II is a valuable contribution as it lists all the more important insects that specialise on various agricultural products in the field. As many of the products are grown in different continents, it is always possible that an insect pest in one land will find its way into another, to become an even worse pest. The introduction of the European White Pierid butterfly into Australia and its phenomenal distribution over most of the continent in a short time will serve to remind Australians of the menace of such introductions.

Part III deals with insects that have proved a serious economic problem in agriculture, horticulture and forestry. The insects are listed in alphabetical order under their various Orders and Families. Many details of life histories are given and countries where damage has been caused are indicated. This section is very fully written up and comprises about half of the volume.

A short account of the more or less successful attempts at biological control of various noxious weeds is given in Part IV. The more important plants dealt with are the Piri Piri Burr of New Zealand, *Lantana* in several parts of the Empire, Blackberry in Australia and New Zealand, Prickly Pear in Australia and South Africa, St. John's Wort in Australia and Ragwort in New Zealand and Australia.

The last part is devoted to a discussion on plant quarantine, virus vectors, insect control and research, and is a very interesting section. The author stresses the great need for more regional handbooks dealing with insect pests. These exist in a few parts of the Commonwealth but many parts are not provided for.

Many people to-day believe that future control of insects will be a matter for chemists and engineers, rather than biologists. Perusal of this book will serve to indicate the valuable work done by biologists and the tremendous scope still remaining for biological research.

As a frontispiece is given a fine photograph of Sir Guy Marshall, one-time Director of the Imperial Institute of Entomology, who did so much to organise Commonwealth co-operation in economic entomology.

All workers in applied entomology will find this book a stimulus and a most useful work of reference.

F. E. WILSON.

DISEASE IN PLANTS
AN INTRODUCTION TO AGRICULTURAL PHYTOPATHOLOGY

By N. E. STEVENS and R. B. STEVENS

(*Chronica Botanica, Waltham, Mass., and N. H. Seward, Melbourne*, 1952, 219 *pp.* $4.75).

This text is the first volume in the series "Manual of the Plant Sciences," a series planned to consist of a twelve-volume review of botanical science at the present day.

Disease in plants has been the subject of many books but almost without exception they have presented the subject in a way that has become orthodox, relying on the descriptions of particular diseases to illuminate the underlying principles which are involved. It is not so with this volume; emphasis centres on the discussion of general principles which will prove useful in the understanding of the science and practice of plant pathology. Diseases of plants are caused by two chief types of influence; (1) the injuricus action of certain environmental conditions, and (2) the attacks of living organisms. It is impossible to keep the two influences apart, for an unfavourable environment to the host plant may prove favourable to the parasite attacking it, and it is this dual action which is so well integrated in this book.

The format of the text is such that there is a tendency for each chapter to be an entity in itself and the somewhat sudden transition from one idea to another may distract. Some chapters suffer from excessive abbreviation, e.g. Bacteria and Fungi are dismissed in approximately seven pages, parasitic flowering plants, nematodes and insects in three pages. This criticism may give an unfair picture for when taken as a whole the contents are exceedingly well balanced and cover an immense field.

The middle chapters may be summed up under the general heading of factors influencing the development of pathogenic diseases. They include the host, the pathogen, weather and soil, insects, variation and physiological specialization in plant pathogens. These chapters are all excellent. It is pleasing to note here that local work is included in a general treatise of this type. Millikan's contribution to our understanding of flag smut is given eminence in the chapter on weather and soil. The later chapters covering disease control summarize the various approaches to this aspect of the subject in a masterly way and the student has here a wealth of information that is not easily accessible to him.

Each chapter has a short but well chosen reference list; it seems a pity that its method of presentation is somewhat wasteful and tends to emphasize the isolation of one chapter from the next.

This work is a valuable addition to the literature on the subject and, although written in America, contains a body of knowledge which is common to plant disease problems everywhere. It is beautifully illustrated with rather exciting figures, a welcome change from the dreary repetition of older text-figures which appear again and again in many scientific books. It is enhanced by some reproductions from old volumes, particularly two from "La Belgique Horticole" which spotlight the advances made in spraying techniques since Millardet and others developed Bordeaux mixture.

ETHEL McLENNAN.

POULTRY HUSBANDRY

By MORLEY A. JULL

(*McGraw-Hill Book Company, Inc., New York 4th Ed.* 1951, 526 *pp.* $6.00).

This book is intended as a text book for students and also as a reference for the practical poultry farmer. In the opinion of this reviewer, with certain reservations, it fulfils this function very well. The reservations relate to usefulness of the book in Australia; Professor Jull has written for conditions in North America and these conditions—climate, available feeding stuffs and markets—are not directly applicable in Australia. This does not alter the fact that the fundamental principles laid down are sound, but it does mean that local readers must use common sense in interpretation.

In this book Jull covers the whole of Poultry Husbandry, including three chapters on marketing and the economics of production, as well as the more usual topics of breeding, rearing, housing and feeding. The chapters on marketing, even though written for American conditions, should provide much food for thought by those engaged in the industry locally. The treatment of breeding principles and practice is clear and readable without over-simplification of modern trends of thought in poultry genetics. Similarly the information on incubation and rearing is comprehensive and directly applicable to local conditions. As may be expected the chapters on feeding contain little about the most recent developments in the use of antibiotics in poultry nutrition but the fundamentals of poultry nutrition, which have not changed, are there.

Chapters are conveniently broken up under headings and subheadings, which, with the comprehensive "selected literature references" at the end of each chapter and the index of subject matter, makes the whole a convenient reference book. The style throughout is clear and concise with adequate illustrations.

For the practical man there is information on labour saving chore routine, types of nests, details of how to construct simple equipment, as well as a wealth of technical detail.

"Poultry Husbandry" can be safely recommended as a text book and as a guide for the intelligent practical man.

IRENE J. STEWART.

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